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INFLUENCE OF POST-INOCULUM AIR TEMPERATURE MAXIMA ON SURVIVAL OF *PHYTOPHTHORA INFESTANS* IN POTATO LEAVES[1]

JACK R. WALLIN[2] AND WM. G. HOYMAN[3]

Reproduction and secondary infection are key processes in the life cycle of the late blight fungus, *Phytophthora infestans*, (Mont.) de Bary. These processes involve the phenomena of spore formation, spore germination, host penetration and the subsequent growth of the fungus mycelium in the host tissues. If the cycle is broken by a failure of one of these phenomena, the fungus dies. More accurate and precise predictions of the late blight epiphytotics will be possible when the temperature and time limits of these processes are understood thoroughly and interpreted accurately.

Certain temperature, humidity and time limits have been defined for each of the above-mentioned phenomena (1,5). One limit suggested was that a temperature maximum of 95° F. occurring as early as 24 hours after inoculation was lethal to the fungus developing in the host tissue (1). This so-called lethal temperature limit was accepted and incorporated in late blight forecasts issued in the North Central States.[4]

However, during 1954 (8), greenhouse cross-inoculation trials with *P. infestans* on susceptible potato and tomato varieties revealed that the late blight fungus damaged as much as 100 per cent of the foliage of potato plants exposed to air temperatures of 98-100° F., 20 hours after inoculation. This finding challenged the validity of the assumption that a temperature maximum of 95° F. 24 hours after inoculation would kill the incubating fungus.

The present study, an elaboration of an earlier presentation (3), was conducted to determine the influence of certain post-inoculation air temperature maxima $\lesseqgtr$ 95° F. on the survival of *P. infestans* in potato leaves.

MATERIALS AND METHODS

Isolates of *P. infestans* were obtained from potato tubers and leaves. Sporangia from such plant parts were mass transferred to autoclaved peas. Culture 35, a monozoospore line, was the only exception.

Culture 1 was isolated from a North Dakota Triumph tuber.

Culture 35 was a monozoospore line obtained from culture 1.

Cultures SB and 105 were subcultures from a tuber culture of the variety Progress grown during 1954 at Scottsbluff, Nebraska.

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Journal Paper No. J-3352 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa Project No. 1163. Report of an investigation conducted under a regional project of the Research and Marketing Act (RMA Title II) in cooperation with the Iowa Agricultural and Home Economics Experiment Station, Crops Research Division, Plant Disease Reporting Section, United States Department of Agriculture.

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[4]Late blight forecasts for the North Central States have been issued since 1950 by the regional office of the Plant Disease Reporting Section at Ames, Iowa.

Culture 104 was isolated from a Red Pontiac plant grown at Hollandale, Minnesota.

The Red Pontiac variety was used because of its susceptibility to *P. infestans* and the seed was from a virus-free strain the junior author had maintained for several years.

Cut seed pieces with two or more eyes were planted to insure abundant foliage. The plants were grown in 6-inch pots located on the same greenhouse bench. Supplemental incandescent light was provided during March from 7 P.M. to 5 A.M. An adequate supply of 6-inch plants for inoculation was maintained by making frequent plantings from March 1 to July 1. The five cultures were maintained on detached Red Pontiac leaves during the entire experiment. The covered containers with the detached leaves were maintained in a chamber where the air temperature ranged from 70-75° F. and the relative humidity 100 per cent. Under these conditions, abundant sporangia were produced and present whenever inocula were needed.

The spores were washed from the detached leaves with glass-distilled water and were caught in a beaker. The spore suspension was transferred to an atomizer and sprayed on the plants or detached leaves until the entire upper surfaces of the leaves appeared wet. Separate glassware was used for each culture to preclude interculture contamination. The plants or detached leaves were inoculated in an isolated room before they were placed in a late blight chamber (2) especially designed for this study.

In eight trials, as shown in table 1, different series of whole plants were inoculated with each of the five cultures. Immediately after a group of plants were inoculated with one culture, it was placed in the chamber where the temperature ranged from 54-65° F. and the relative humidity was 100 per cent. The inoculated material was held under these conditions for a minimum of 15 hours before the temperature was raised gradually to 105, 106, 108, 109, 110 and 115° F. The temperature maxima were obtained by raising the steam-heated greenhouse temperature and by an automatic fan-forced electric heater placed in the chamber. The length of the heating period was determined by the desired temperature maximum. The duration of the maxima temperature exposures for all trials reported in tables 1 and 2 ranged from 30 to 60 minutes.

Inoculated control plants were removed from the chamber and placed on the floor at the time the temperature was raised. Since they were in the greenhouse housing the late blight chamber, they were subjected to abnormally high greenhouse temperatures (Table 1). After the chamber temperature was gradually lowered to 95° F. or less, the control plants were placed in the chamber and evaluated with the inoculated plants 5 to 12 days after inoculation.

In each of four additional trials, five detached leaves of the Red Pontiac variety, lying on moist sphagnum moss in wooden flats, were inoculated with spores from each culture and incubated in the late blight chamber for 12 hours at temperatures of 58-65° F., with 100 per cent relative humidity, before they were subjected to maximum temperatures of 83, 95, 105, and 108° F.

The tolerance of each culture of *P. infestans* to the post-inoculation temperatures was evaluated by estimating the percentage of blighted foliage

TABLE 1.—*Percentage of Red Pontiac foliage blighted by 5 cultures of Phytophthora infestans incubated for 7 different time intervals and exposed to 6 different temperature maxima.*

Trial	Treatment	Hrs. Incu-bated	Hrs. to Reach Temp. Max.[1]	Temp. Range °F.	Percentage of Blighted Foliage Produced by Culture				
					1	35	104	105	SB
A	Control	19.5		63-76	33	90	95	90	95
	Heated	19.5	2.5	63-105	25	90	95	90	95
B	Control	15		64-86	90	90	90	90	90
	Heated	15	6	64-106	10	0	0	0	0
C	Control	16.5		59-95	60	75	75	80	90
	Heated	16.5	5.5	59-106	10	0	0	0	1
D	Control	23		54-87	96	85	95	90	97
	Heated	23	4	54-106	75	60	60	70	60
E	Control	40.5		62-93	20	0.5	85	85	80
	Heated	40.5	2.5	62-108	0.5	5	85	85	80
F	Control	40		62-90	75	75	75	80	75
	Heated	40	5	62-109	5	2	5	5	75
G	Control	18		63-87	92	93	90	93	98
	Heated	18	6	63-110	10	5	2	75	92
H	Control	40		63-86	95	90	96	95	91
	Heated	40	7	63-115	5	1	0	0	8

[1]Number hours of heating required to obtain temperature maximum after incubation.

TABLE 2.—*Percentage of detached Red Pontiac leaf area blighted by 5 cultures of Phytophthora infestans, incubated 12 hours and exposed to 4 different temperature maxima.*

Trial	Treatment	Hrs. Incu-bated	Hrs. to Reach Temp. Max.[1]	Temp. Range °F.	Percentage of Blighted Foliage Produced by Culture				
					1	35	104	105	SB
A	Control	12		58-70	100	40	33	100	95
	Heated	12	2	58-83	95	40	33	100	95
B	Control	12		60-70	100	50	100	100	100
	Heated	12	2	60-95	100	50	95	100	95
C	Control	12		64-70	75	100	100	90	100
	Heated	12	8	64-105	5	10	50	40	75
D	Control	12		65-71	75	75	66	25	75
	Heated	12	6	65-108	0	0	0	0	0

[1]Number hours of heating required to obtain temperature maximum after incubation.

or leaf-area blight it produced. The cultures producing the greatest amount were considered the most tolerant of the given temperature maximum.

Results and Conclusions

The results obtained from the trials involving whole plants are shown in table 1.

All cultures survived exposure to 105° F. air temperature 22 hours after spores were sprayed on the plant surfaces and produced the same percentage of blighted foliage as the controls with the exception of culture 1. In the latter instance there was a difference of 8 per cent.

Exposure to 106° F. 21 hours after inoculation was lethal to cultures 35, 104, 105, and SB but not to 1. A temperature maximum of 106° F., 22 hours after inoculation, killed cultures 35, 104, and 105 but not 1 or SB. SB and 105 were subcultures of the same culture. The air temperature of 106° F., 27 hours after inoculation, retarded the growth of the cultures but all produced rather high percentages of blighted foliage.

All cultures survived exposure to 108° F. 43 hours after inoculation. Apparently, the inocula for cultures 1 and 35 were not effective in this test because they produced low percentages of blighted foliage on the control plants. The control for culture 35 produced less blighted foliage than the heated culture.

All cultures survived exposure to 109° F. 45 hours after inoculation, SB being the most tolerant. SB and 105, sister cultures, varied in their tolerance.

All cultures survived exposure to 110° F. 24 hours after inoculation. Sister cultures SB and 105 were the most tolerant.

An air temperature of 115° F. 47 hours after inoculation was lethal to cultures 104 and 105 but not 1, 35, and SB. The survival of these cultures at this maximum was surprising. This is the first report of *P. infestans* surviving in infested leaves exposed to such heat. Survival in stem lesions exposed to temperature maxima of 105 to 110° F. during a 6-day period was reported in 1934 (1). However, in this case the fungus was well established in obvious lesions.

Cultures 1 and SB were more tolerant to heat than the other cultures. The survival of culture 1 was interesting because it was obtained from a North Dakota tuber. Culture SB tolerated more adverse temperature maxima and caused a higher percentage of blighted foliage in some trials than culture 1. For example, SB blighted about 70 per cent more foliage (trial F) than the other cultures after exposure to 109° F. 45 hours post-inoculation. SB was expected to tolerate higher temperatures because it was obtained from a tuber grown at Scottsbluff, Nebraska, during 1954. During July 1954, the infected potato vines were exposed to temperatures $\geqq$ 90° F. for 13 consecutive days, 4 of which had temperature maxima of 103, 107, 105 and 103° F. Furthermore, there were 25 days when the temperature maximum was $\geqq$ 90° F.

These results suggested that the cultures differed in their ability to survive exposure to certain high temperature maxima. Furthermore, as shown by the controls in trial C, all cultures of the fungus tolerated a temperature maximum of 95° F. 16.5 hours after inoculation. The post-inoculation air temperatures tolerated by some of the cultures were considerably higher than previously reported (1).

The results from the detached leaf trials (Table 2) show that none of the cultures survived exposure to 108° F. 18 hours after inoculation. However, 20 hours after inoculation, all cultures survived an exposure to 105° F. At this temperature, the results indicated that cultures 104, 105 and SB were more tolerant than 1 and 35. Therefore, an air temperature of 105° F., 20 hours after inoculation, did not inhibit growth of the fungus in detached leaves. Other investigators (4), have demonstrated that some cultures of *P. infestans*, growing in culture media, survived a 48-hour exposure to 95° F.

Although leaf temperature measurements were not made in the experiments cited herein, the results of earlier investigations (6, 7, 8) showed that, in the absence of direct insolation, the leaf and air temperatures were approximately the same.

Summary

Five cultures of *P. infestans*, growing in potato leaves, were subjected to air temperatures of 105° F. 22 hours; 106° F. 21, 22 and 27 hours; 108° F. 43 hours; 109° F. 45 hours; 110° F. 24 hours and 115° F. 47 hours after inoculation.

All cultures survived 105° F. Only culture 1 survived 106° F. 21 hours after inoculation although two cultures (1 and SB) survived exposure to 106° F. 22 hours after inoculation. All cultures survived this temperature 27 hours after inoculation. All cultures survived 108° F. 43 hours after inoculation. Moreover, the five cultures survived 109° F. and 110° F. 45 and 24 hours, respectively, after inoculation. Three cultures, (1, 35 and SB) survived exposure to 115° F. 47 hours after inoculation. The same five cultures, growing in detached potato leaves, were exposed to air temperatures of 83, 95, 105 and 108° F. 14, 14, 20 and 18 hours respectively, after inoculation. The five cultures varied in their tolerance to 105° F. and none survived the maximum of 108° F.

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NORDAK AND NORGLEAM
TWO NEW WHITE-SKINNED POTATO VARIETIES WITH EARLY MATURITY AND FIELD RESISTANCE TO VIRUS Y[1]

R. H. Johansen,[2] N. Sandar,[2] W. G. Hoyman[3] and E. P. Lana[4]

On August 1, 1957 the Horticulture Department, North Dakota Agricultural College, Fargo, North Dakota, announced the release of Nordak and Norgleam. Both potato varieties have field resistance to virus Y, good cooking quality and early maturity.

Norgleam and Nordak were tested in North Dakota and other areas under the pedigree numbers ND 457-1-16 (Norgleam) and ND 457-1-10 (Nordak). They are sister selections resulting from self pollinating a North Dakota selection ND 457-1. The parent, ND 457-1, possessed smooth tuber type, shallow eyes and a high degree of field resistance to virus Y. The seedlings from this self-pollinated selection were grown in the greenhouse at the North Dakota Agricultural College in 1949 and the original selections were made in the field at the Langdon Branch Station, Langdon, North Dakota, in 1950. Since 1953 these varieties have been tested in North Dakota and other areas for yield, per cent total solids, culinary qualities and reaction to virus Y and scab.

The Pedigree of Norgleam and Nordak is as follows:

Norgleam (ND 457-1-16)	Selfed (ND 457-1)	Minn. 92.36-5	Minn. 17-2	*Solanum acaule* x 63-5S
			x	
			Houma	Katahdin x Charles Downing
		x		
Nordak (ND 457-1-10)		Sebago	Katahdin	B 24642 x B 40568
			x	
			Chippewa	B 24642 x B 40568

Description of Varieties

NORGLEAM

PLANTS: Medium large, spreading; *stems,* medium thick, prominently angled; *nodes,* slightly swollen, green; *internodes,* pigmented, purple; *wings,* medium waved, single, scantily pubescent, green; *stipules,* on leaves, large, green, scantily pubescent, clasping; *leaves,* medium large, slightly closed and green; *midribs,* green; *petioles,* green and pubescent; *terminal leaflets,* medium in size; ovate, acute, partly truncate and asymmetrical;

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primary leaflets, medium in size, ovate, four pairs, opposite to alternate, mean length 64.9 ± 1.4 mm. (2.56 inches), mean width 35.6 ± 0.63 mm. (1.40 inches), index width to length 54.9 ± 0.51 mm.; *petiolules,* green, pubescent, quite long; *secondary leaflets,* many between pairs of primary leaflets; *tertiary leaflets,* many; *inflorescence,* erect, slightly branched; *leafy bract,* none; *peduncles,* in axils of main stem, medium long, green, scantily pubescent; *pedicels,* medium long, slightly pigmented, scantily pubescent; *corky ring,* conspicuous green.

FLOWERS: *Buds,* slightly pigmented; *calyx lobes,* medium in length, tips curved, green and pubescent; *corolla,* medium large, diameter 25-30 mm. white; *anthers,* orange yellow, pollen abundant, good quality; *style* straight; *stigma,* globose, multilobed and green.

TUBERS: Medium oblong to slightly round. Mean length 89.2 ± 0.75 mm. (3.51 inches), mean width 74.9 ± 0.62 mm. (2.95 inches), mean thickness 62.3 ± 0.55 mm. (2.45 inches), indexes width to length 84.3 ± 0.93 mm. thickness to length 70.8 ± 0.94, and thickness to width 84.0 ± 1.10. *Skin,* smooth, white; *eyes,* shallow, same color as skin; *eyebrows,* long, slightly curved prominent; *flesh,* very white; *sprouts,* purple at base when developed in the dark; *maturity,* early.

NORDAK

PLANTS: Medium, very erect; *stems,* medium thick, prominently angled; *nodes,* swollen, green; *internodes,* pigmented, purple; *wings,* prominent, medium waved, single, scantily pubescent, green; *stipules,* on leaves, small, green, clasping; *leaves,* medium, slightly closed, green; *midribs,* not pigmented, scantily pubescent; *petioles,* green, pubescent; *terminal leaflets,* medium in size, ovate, acute, truncate and partly asymmetrical; *primary leaflets,* medium to small in size, ovate, four to five pairs, mean length 58.2 ± 1.02 mm. (2.29 inches), mean width 30.7 ± 0.55 mm. (1.21 inches), with index width to length 52.8 ± 0.99 mm.; *petiolules,* green, pubescent; *secondary leaflets,* many between pairs of primary leaflets and at junction of midrib; *tertiary leaflets,* few; *inflorescence,* slightly branched; *leafy bracts,* none; *peduncles,* in axils of petioles and main stem, medium length, pigmented, scantily pubescent; *pedicels,* long to medium, much pigmented, scantily pubescent; *corky ring,* conspicuous, green.

FLOWERS: *Buds,* slightly pigmented; *calyx lobes,* medium in length, tips, recurved, green, pubescent; *corolla,* medium large, white; *anthers,* orange yellow; *pollen,* abundant, good quality; *style,* straight; *stigma,* globose, multilobed and green.

TUBERS: Medium oblong to round, mean length 86.4 ± 0.77 mm. (3.40 inches), mean width 76.1 ± 0.60 mm. (3.00 inches), mean thickness 63.2 ± 0.56 mm. (2.49 inches), indexes width to length 88.3 ± 0.75, thickness to length 73.6 ± 0.84, and thickness to width 83.2 ± 0.75; *skin,* smooth, white; *eyes,* shallow, same color as skin; *eyebrows,* long, slightly curved, prominent; *flesh,* very white; *sprouts,* purple at base when developed in the dark; *maturity,* medium early.

Characteristics of Norgleam and Nordak

Nordak and Norgleam are very similar in many respects. Tubers of both varieties have white skin, round to oblong shape, early maturity, excellent cooking quality, shallow eyes, early yielding ability and field resistance to virus Y. In maturity, Nordak is as early as Red Warba whereas Norgleam resembles Irish Cobbler. The plant growth of Norgleam is spreading while that of Nordak is quite erect.

The pitted and russet types of scab have been observed on both varieties in North Dakota and other areas. Greenhouse tests have shown that both varieties are susceptible to the fungus which causes late blight and also to virus X. Both varieties have remained free from silver scurf when grown at Northwood, North Dakota, where this disease has been severe on Red Pontiac and on some other selections and varieties. Field and greenhouse tests have shown that both varieties possess a considerable degree of field resistance to virus Y. Because of their short stolons, Nordak and Norgleam are very susceptible to sun-greening unless adequately hilled. Under some conditions they are susceptible to internal necrosis and vascular discoloration.

Extensive field trials have shown that Nordak and Norgleam are adapted to North Dakota and to certain other states and to several areas of Canada. The ability to produce high marketable yields early in the season is an important characteristic of both varieties. As indicated in table 1, early harvest variety trials conducted in North Dakota during 1955-1956 showed that Norgleam produced yields higher than Triumph, Early Gem and Red Pontiac when hervested during mid-August. Norgleam, when harvested in mid-September at Park River and Grand Forks, North Dakota, produced yields higher than Triumph and Early Gem but not Red Pontiac. Under irrigation at Williston, North Dakota, Nordak outyielded Triumph and Early Gem.

Table 1.—*Average yields and per cent total solids* of five potato varieties grown at three locations in North Dakota and harvested on two dates, 1955 and 1956.*

Variety	Grand Forks and Park River				Williston (Irrigated)	
	Early Harvest August 15		Late Harvest September 15		Late Harvest September 15	
	Marketable Yield Per Acre	Total Solids	Total Yield Per Acre	Total Solids	Total Yield Per Acre	Total Solids
	Bushels	Per Cent	Bushels	Per Cent	Bushels	Per Cent
Norgleam (ND 457-1-16)	247	20.8	346	20.3	488	20.3
Nordak (ND 457-1-10)	217	20.7	324	20.3	518	20.3
Red Pontiac	219	18.4	380	18.1	620	18.4
Triumph	232	19.6	325	18.5	458	19.0
Early Gem	147	18.4	294	17.9	468	19.0

*Yields and per cent total solids of locations and years averaged.

Trials at various locations in North Dakota indicated that Nordak and Norgleam were comparable in yield to Irish Cobbler. Data obtained from the 1956 North Central Regional Variety Trial showed Norgleam and Nordak to have an average yield of 373 and 395 bushels per acre, respectively. In the same trial, Irish Cobbler had an average yield of 362, Triumph 409, and Red Pontiac 540 bushels per acre.

The per cent total solids of Norgleam or Nordak was higher than that of Red Pontiac but comparable to that of Irish Cobbler. In a 4-year test in North Dakota, Norgleam and Nordak had an average of 20.2 per cent total solids whereas Red Pontiac had an average of 17.9.

Chipping trials conducted during 1956 showed that Norgleam and Nordak made unacceptable chips immediately after harvest in August, but produced acceptable chips after a period of storage and reconditioning. When harvested on August 15 and 29, 1957, Norgleam and Nordak made chips comparable in color and yield to Irish Cobbler. Flesh color of Nordak and Norgleam is very white and both varieties have excellent boiling, baking and frying qualities.

Summary

Nordak (ND 457-1-10) and Norgleam (ND 457-1-16) are two white-skinned, early maturing potato varieties. The tubers of both varieties are oblong to round, smooth-skinned and shallow-eyed. Norgleam and Nordak are susceptible to scab, late blight and virus X. Both varieties possess a considerable degree of field resistance to virus Y.

VENTILATION OF CHIPPING POTATOES DURING THE CONDITIONING PERIOD[1]

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In the potato chip industry, improvement in the color of chips from winter-stored potatoes has been a major problem. Many processors and farmers have had difficulty in conditioning such tubers and have indicated in some detail the need for a more accurate study of these problems. Smith (2) indicated that more work should be conducted on ventilation and on various relative humidity levels. This investigation deals with chip color and tuber decay resulting from storage in atmospheres of various relative humidities and chemical compositions.

In a preliminary test, many conditions were investigated that might affect the conditioning of Russet Rural potatoes for use in chipping. Carbon dioxide gas at varying percentages was added to the air both in well and in poorly ventilated containers. Nitrogen was added to others. Moisture was added in some containers, while in others calcium chloride was used to absorb atmospheric moisture and calcium hydroxide was used to absorb carbon dioxide. The effects of pressures, exerted on the tubers, and of rough handling were studied. The pure nitrogen atmosphere led to a rapid decay of tubers; carbon dioxide seemed harmful in large concentrations. Thorton (3) and Denny and Thornton (1) reported similar effects from carbon dioxide. Ventilation to avoid high humidities and condensation of water on the tubers or in the containers seemed especially important. The use of calcium chloride to produce a drier atmosphere might well be investigated further. On the basis of these preliminary tests, the experiment below was performed.

MATERIAL AND METHODS

Russet Rural potatoes stored from September until January were used. The tubers were in good condition, with neither rot, wilting or sprouts. The temperature of the storage was 40° F. when the tubers were removed. Cheese cans with a volume of 15.70 liters which had a small metal tube soldered on the bottom and at the top were used in the ventilation tests. The covers were sealed with scotch tape. Fifty tubers occupied approximately one-half the volume of each can. The tests were conductd at laboratory temperatures of 70° F. Frying tests of the stored potatoes were made at two week intervals.

The following conditions of storage were provided, with three replications in each case:

a. Ventilated with dry air.

One hundred and twenty cc per minute of dry air from the laboratory at 70° F. was continuously passed through the container. The relative humidity was found to be approximately 85 per cent in the containers. No moisture condensation occurred.

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b. Ventilated with moistened air.

Moist air obtained by passing air first through water and then through moistened blotting paper was passed continuously through the potatoes in the containers at the rate of 120 cc per minute. The relative humidity was approximately 100 per cent as indicated by the condensation of droplets of water on the inside of the cover and the side walls of the containers.

c. Ventilated with 10 per cent carbon dioxide modified atmosphere, dry.

A mixture of 90 per cent air and 10 per cent carbon dioxide was passed through the potatoes at a volume of 120 cc. per minute.

d. Poorly ventilated with dry air.

The containers were sealed and all vents closed. The air was changed once a week.

e. Poorly ventilated with moist air.

The tubers were moistened at the beginning and placed immediately into the container. The air was changed once a week.

f. Poorly ventilated with 10 per cent of carbon dioxide.

Carbon dioxide was forced into the upper ventilation tube to obtain a mixture of 90 per cent air and 10 per cent carbon dioxide. The gas was changed once a week.

Five tubers were taken out of each container at 3, 5, 7 and 9 weeks and tested by standard methods for frying potato chips. The color scale used was supplied by Proctor and Gamble Company. Chip color rating with 10 being dark and undesirable and 1 white and highly desirable. At the same time all of the tubers were examined for presence of decay, and decayed tubers were removed and weighed.

The results of decay and chip color are given in the following tables.

TABLE 1.—*Weight loss from decay in per cent over a period of 9 weeks.*

	3 Wks.	5 Wks.	7 Wks.	9 Wks.
Dry air—ventilated	0	0	1.7	4.5
Moist air—ventilated	2.0	4.8	66.8	100.0
10 per cent CO_2 dry air—ventilated	4.0	4.0	17.1	70.6
Dry air—poorly ventilated	34.0	96.4	100.0	..
Moist air—poorly ventilated	100.0	..	..	..
10 per cent CO_2 dry air—poorly ventilated	76.0	100.0	..	..

TABLE 2.—*Chip color ratings at intervals of 2 weeks during conditioning.*

	Intervals in Weeks				
	Start	3 Wks.	5 Wks.	7 Wks.	9 Wks.
Dry air—ventilated	9.50	7.00	5.40	3.05	3.20
Moist air—ventilated	9.50	7.36	6.25	6.10	..
10 per cent CO_2 air—ventilated	9.50	6.00	6.40	6.80	6.06
Dry air—poorly ventilated	9.50	7.40	..	..	..
Moist air—poorly ventilated	9.50	..	..	..	..
10 per cent CO_2 air—poorly ventilated	9.50	7.75	..	..	..

Loss from decay is encountered when potatoes are stored and conditioned for chips at any temperature. The low weight loss from decay of only 4.5 per cent in the ventilated dry air was evidence that potatoes require a continuous supply of fresh atmosphere. All of the ventilated containers had less loss from decay than those poorly ventilated. Containers ventilated with moist air kept the potatoes from complete decay longer than those poorly ventilated with dry air. This would indicate that a continuous supply of dry air was essential in keeping loss from decay at a minimum. The addition of 10 per cent CO_2 to the air with either good or poor ventilation appeared to increase decay. Moist air resulted in a high relative humidity around the potatoes which gave the highest per cent of total decay in both the ventilated and poorly ventilated containers.

The chip color rating of 9.50 at the start of the experiment was very dark for Russet Rural potatoes. It is remarkable that the color of the chips improved to a rating of 3.05 in 7 weeks of conditioning in dry ventilated containers. This color is ideal for the manufacture of potato chips. Although containers ventilated with dry air containing 10 per cent CO_2 resulted in sound potatoes after 9 weeks of conditioning, the color rating of 6.06 made them undesirable for chips.

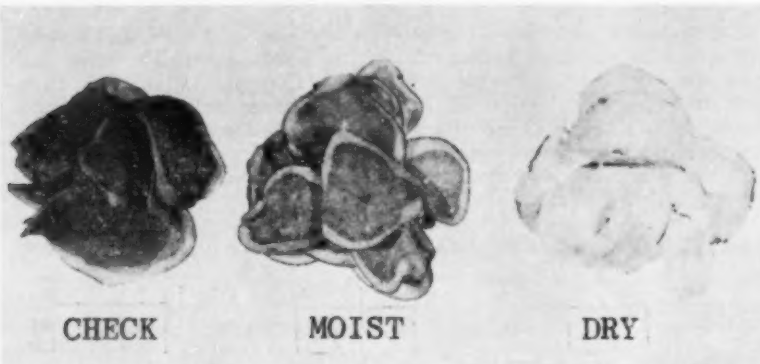

FIGURE 1.—Chip color after seven weeks of conditioning in moist and dry air in comparison to the beginning check.

Check shows chips with a 9.50 color rating from table 2; moist chips with a 6.10 color rating from tubers ventilated with moist air after 7 weeks conditioning; and dry-chips from tubers with a chip rating of 3.05 conditioned in continuous dry air ventilation for 7 weeks (Table 2 and Figure 1).

The chip color improved from a rating of 7.00 at 3 weeks, 5.40 at 5 weeks to 3.05 at 7 weeks (Table 2 and Figure 2).

A slight improvement occurred with time but it was not sufficient to recommend it as a practice for two reasons: 1) chip color was dark even at 7 weeks and 2) a higher percentage of the tubers decayed in this atmosphere than in the containers ventilated with dry air. (Table 1 and Figure 3).

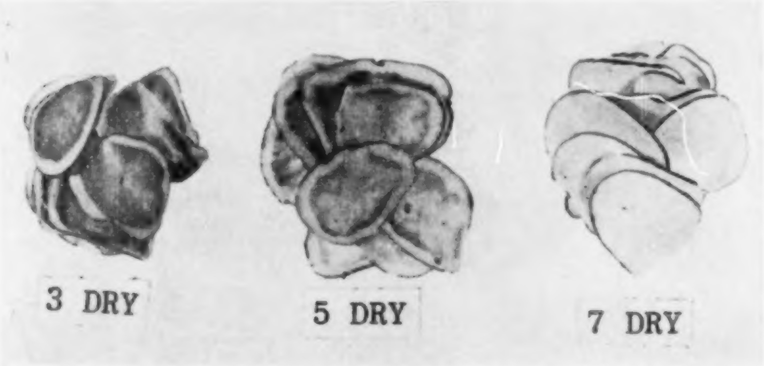

FIGURE 2.—Chip color after 3, 5, and 7 weeks of conditioning in ventilated dry air.

The color of the chips from tubers treated with 10 per cent CO_2 in air and those from the moist air were much inferior to those ventilated with dry air. Only the cortical region of the chips from the first two treatments showed any signs of being conditioned. On the other hand, the chips, made from the center of those tubers ventilated with dry air, were excellent in color (Figure 4).

The tubers in figure 5 had not previously been treated with a sprout inhibitor. Note the minimum sprout growth even when the tubers were held at 70° F. for a period of 9 weeks. A sprout inhibitor might be desirable if the potatoes were to be stored over a longer period.

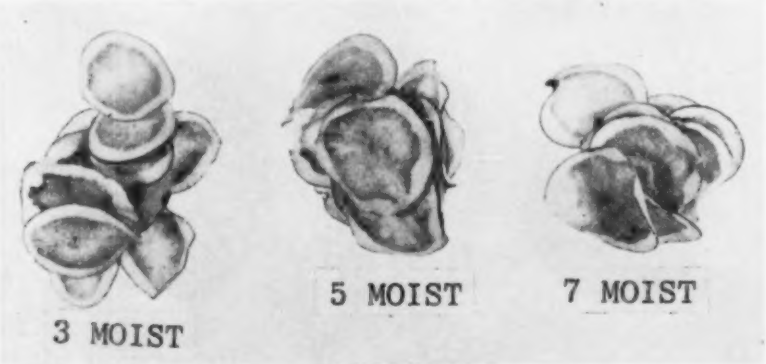

FIGURE 3.—Chip color after 3, 5 and 7 weeks of conditioning in ventilated moist air.

SUMMARY AND RECOMMENDATIONS

Ventilation and modified atmosphere were applied to Russet Rural potatoes during conditioning after storage at 40° F. and their effect on potato chip color and decay was determined. Poor ventilation did not

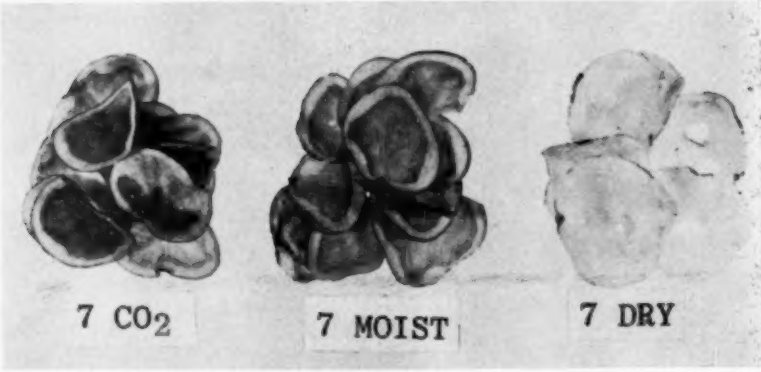

FIGURE 4.—Chip color after 7 weeks of conditioning potatoes subjected to ventilation with 10 per cent CO_2 gas, moist, and dry air ventilation.

produce satisfactory chips, and was accompanied by serious decay where a high relative humidity was induced.

Ventilation to give a relative humidity of approximately 85 per cent gave far more satisfactory chips than did ventilation with air approaching 100 per cent relative humidity. Carbon dioxide in relatively high amounts (10 per cent in air) was somewhat detrimental to good conditioning even in an atmosphere at a satisfactory relative humidity.

FIGURE 5.—Tubers ventilated with a continuous flow of dry air for 9 weeks.

Prevention of tuber decay and good chip color appear to be highly dependent on dry air passing freely between the potatoes. Good ventilation with dry air prevented condensation on the potatoes or the container.

Potatoes should not be allowed to become wet on the surface at any time during the conditioning period.

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3. Thornton, N. C. 1935. Carbon Dioxide Storage VIII. Chemical changes in potato tubers resulting from exposure to carbon dioxide. Contrib. Boyce Thompson Institute. 7: 113-118.

SPECIFIC GRAVITY OF DIFFERENT ZONES WITHIN POTATO TUBERS[1,2]

M. K. SHARMA, D. R. ISLEIB AND S. T. DEXTER[3]

Differences in firmness have been noticed between zones of cooked potatoes in tests performed by the authors. Some of these differences could be explained on the basis of variable dry matter from zone to zone, whereas other differences distinctly contradicted the predictions of any theory correlating firmness after cooking with dry matter content. In an attempt to understand such apparent inconsistencies, research was under taken to examine tubers for physical and chemical properties related to this cooking characteristic. The present paper considers the magnitude of the differences in specific gravity (dry matter) between zones of tubers of a number of varieties. The influence of specific gravity and chemical composition on cooking characteristics will be described in a paper at a later date.

REVIEW OF LITERATURE

Differences in chemical composition between tuber zones have long been recognized. Coudon and Bussard (1) reported that percentage of water and total nitrogen increased and percentage starch decreased from cortex to core (pith), and East (2) confirmed these findings. Johnson and Boyle (5) noted that the percentage of dry matter in tubers of a single variety varied from 21.07 to 27.18 and the starch percentage varied from 14.65 to 20.16. Glynne and Jackson (3) reported that the percentage dry matter in tubers was lowest in the skin and increased to the inner cortical layer, then decreased towards the center of the tuber. Goldthwaite (4) determined the chemical composition of cortex and medullary areas of individual tubers and found that the percentages of dry matter, starch, total carbohydrate and ash were greater in the cortex than in the medullary area. No two potatoes of identical composition were found in the same variety, in the same group, or in the same hill.

Thiessen (6) found distinct differences in composition of different areas of a single potato tuber. The stem end of tubers contained more starch, less water and less crude fiber than did the bud ends. Outer medullary areas had a slightly lower percentage of starch and a higher percentage of water than cortical zones whereas inner medullary areas had a higher proportion of crude fiber, pectin and nitrogen. Thiessen also found that no two tubers taken from the same lot had the same chemical composition. Whittenberger and Nutting (7) noticed that, in general, tissues of highest specific gravity occurred on both sides of the vascular ring, and tissues of lowest specific gravity were in the central pith or medulla. The starch content ranged from 10 per cent in the central pith to about 25 per cent in the peripheral zone.

There is general agreement that the dry matter increases from the periphery of the tuber towards the vascular region, thence decreasing to

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[2]Journal Article No. 2249, Michigan Agricultural Experiment Station, East Lansing, Mich.
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the center of the tuber. Thus much of the dry matter is contained in the storage parenchyma associated with the phloem, less in the cortex and least in the pith.

Materials and Methods

The terminology of tuber anatomy found in the literature is far from consistent. For clarity, the three zones distinguished in this paper have been defined as follows: Zone one (the outer zone) extends from the tuber surface approximately to the vascular ring, thus including periderm, cortex, and some phloem parenchyma as well as vascular tissue. It corresponds to the zone called "cortex" by many authors. The second zone is bounded peripherally by the vascular ring and extends slightly less than halfway toward the center of the tuber. It includes much scattered vascular tissue with associated parenchyma and some pith parenchyma. The third or inner zone (pith) comprises the remainder of the tuber and is largely pith parenchyma.

Tubers of 14 varieties grown at East Lansing, Michigan in 1956 and 15 varieties grown in 1957 were used in this study. Each sample consisted of ten medium-sized tubers selected at random from a 100-foot row dug when the vines were dead. Each tuber was washed, weighed with an accuracy of ± 0.01 gram in air and in water and specific gravity calculated according to the formula:

$$\text{Specific gravity} = \frac{\text{Weight in air}}{\text{Weight in air} - \text{Weight in water}}$$

Zone one was pared from the tuber, and the remaining tuber tissue was reweighed in air and in water. Zone two then was removed, and zone three was weighed similarly. From these data, specific gravity of each of the three zones was calculated. The results from ten tubers of each variety were averaged and the means are presented in tables 1 and 3.

Results and Discussion.

Table 1 shows the specific gravity of whole tubers and three different zones of tubers of 14 varieties grown in 1956. Table 2 shows the same data, calculated as per cent after deleting the constant 1.000 from each determination and taking the entire tuber as 100. In most cases zone two was highest, and zone three was invariably lowest in specific gravity. In general, tubers of varieties high in specific gravity showed wide differences in specific gravity between zone three and the other two zones. The varieties whose tubers were low in specific gravity differed little in specific gravity between the zones. Means of the varieties revealed a great difference between either zone one or two and zone three, but little difference between zone one and zone two.

Table 3 compares the specific gravity of entire tubers and three different portions of the tubers of 15 potato varieties grown in 1957. The same data, calculated as per cent after deleting the constant 1.000 from each determination and taking the entire tuber as 100, are shown in table 4. The results were almost identical to those of 1956. In most cases zone two was highest in specific gravity. Again, varieties of high specific

TABLE 1.—*Specific gravity of whole and different zones of potato tubers of 14 varieties grown during 1956 (means of ten tubers).*

No.	Variety	Whole Tuber	Zone 1	Zone 2	Zone 3
1.	Red LaSoda	1.0731	1.0727	1.0836	1.0623
2.	Waseca	1.0734	1.0723	1.0813	1.0616
3.	Onaway	1.0745	1.0713	1.0805	1.0628
4.	Chippewa	1.0795	1.0807	1.0771	1.0726
5.	Sebago	1.0807	1.0855	1.0847	1.0654
6.	Pontiac	1.0815	1.0814	1.0878	1.0675
7.	Katahdin	1.0826	1.0845	1.0910	1.0689
8.	Osage	1.0860	1.0894	1.0909	1.0697
9.	Russet Rural	1.0870	1.0862	1.0901	1.0674
10.	Tawa	1.0891	1.0946	1.0952	1.0678
11.	Delus	1.0948	1.1001	1.0949	1.0631
12.	Saco	1.0954	1.1014	1.0939	1.0677
13.	Green Mountain	1.0970	1.1032	1.0950	1.0751
14.	Merrimack	1.1029	1.1089	1.0982	1.0717
	Mean	1.0855	1.0880	1.0889	1.0674

TABLE 2.—*Specific gravity of different tuber zones from 14 varieties of potatoes grown in 1956, expressed as percentage of entire tuber specific gravity.**

No.	Variety	Whole Tuber	Zone 1	Zone 2	Zone 3
1.	Red LaSoda	100	99.45	114.36	85.22
2.	Waseca	100	98.50	110.76	83.92
3.	Onaway	100	95.70	108.05	84.29
4.	Chippewa	100	101.50	96.98	91.32
5.	Sebago	100	105.94	104.95	81.04
6.	Pontiac	100	99.87	107.73	82.82
7.	Katahdin	100	102.30	110.16	83.41
8.	Osage	100	103.95	105.69	81.04
9.	Russet Rural	100	99.08	103.56	77.47
10.	Tawa	100	106.17	106.84	76.09
11.	Delus	100	105.59	110.10	66.56
12.	Saco	100	106.28	98.42	70.96
13.	Green Mountain	100	106.39	97.93	77.42
14.	Merrimack	100	105.83	95.43	69.67
	Mean	100	102.61	104.35	79.37

*Percentage calculated after deleting the constant 1.000 from each determination.

gravity had greater differences between zones one and three than varieties which were low in specific gravity. Means of all varieties indicated very little difference between specific gravity of zone one and zone two and greater difference between either of these and zone three. The difference between zones one and three was greater in 1956 than in 1957. A comparison between varieties high and low in specific gravity revealed that zone three of all varieties differed but little in specific gravity, while specific gravity differences between entire tubers were great due to large differences in the outer zones between varieties. Maximum differences between zones within Delus and other high specific gravity tubers were at least as great (0.0370 between zones one and three of Delus in 1956) as the maximum

TABLE 3.—*Specific gravity of whole and different zones of potato tubers of 15 varieties grown during 1957 (means of ten tubers).*

No.	Variety	Whole Tuber	Zone 1	Zone 2	Zone 3
1.	Sebago	1.0611	1.0608	1.0663	1.0508
2.	Pontiac	1.0615	1.0584	1.0688	1.0587
3.	Onaway	1.0627	1.0636	1.0614	1.0626
4.	Chippewa	1.0654	1.0675	1.0686	1.0634
5.	Ontario	1.0668	1.0710	1.0676	1.0503
6.	Tawa	1.0672	1.0632	1.0760	1.0597
7.	Osage	1.0712	1.0650	1.0842	1.0685
8.	Katahdin	1.0723	1.0750	1.0752	1.0565
9.	Irish Cobbler	1.0732	1.0705	1.0795	1.0678
10.	Cherokee	1.0758	1.0789	1.0756	1.0593
11.	Menominee	1.0767	1.0807	1.0782	1.0543
12.	Russet Rural	1.0775	1.0791	1.0831	1.0670
13.	Delus	1.0808	1.0869	1.0810	1.0593
14.	Merrimack	1.0822	1.0804	1.0891	1.0710
15.	Green Mountain	1.0930	1.0957	1.0916	1.0713
	Mean	1.0725	1.0731	1.0764	1.0614

TABLE 4.—*Specific gravity of different tuber zones from 15 varieties of potatoes grown in 1957, expressed as percentage of entire tuber specific gravity.**

No.	Variety	Whole Tuber	Zone 1	Zone 2	Zone 3
1.	Sebago	100	99.51	108.51	83.14
2.	Pontiac	100	94.96	111.87	95.77
3.	Onaway	100	101.43	97.92	99.82
4.	Chippewa	100	103.21	104.89	96.94
5.	Ontario	100	106.29	101.19	75.30
6.	Tawa	100	94.05	113.09	88.84
7.	Osage	100	91.29	118.26	96.21
8.	Katahdin	100	103.71	104.01	78.14
9.	Irish Cobbler	100	96.31	108.61	92.62
10.	Cherokee	100	104.09	99.73	78.23
11.	Menominee	100	105.21	101.95	70.79
12.	Russet Rural	100	100.13	107.23	86.45
13.	Delus	100	107.55	100.25	73.39
14.	Merrimack	100	97.81	108.39	86.37
15.	Green Mountain	100	102.90	98.49	76.67
	Mean	100	100.56	105.63	85.24

*Percentage calculated after deleting the constant 1.000 from each determination.

variation between low and high specific gravity varieties (0.0298 between Red LaSoda and Merrimack in 1956).

The variation in specific gravity between zones one and three may be compared in greater detail in the varieties Chippewa (low in specific gravity) and Delus, (high in specific gravity). Maximum variation between zones of the Chippewa tubers was 0.0081 in 1956 and 0.0041 in 1957. This uniformity of dry matter distribution was reflected in the uniform texture of Chippewa tubers after cooking. In contrast, the maximum specific gravity difference between zones of the Delus tubers was 0.0370 in 1956 and 0.0276 in 1957, and texture after cooking varied markedly within these

tubers. Perhaps this specific gravity difference was related to the tendency of Delus and other varieties of high dry matter to slough during boiling.

Summary and Conclusions

The specific gravity of three concentric zones within tubers of 19 potato varieties was determined over the two-year period 1956-1957. During this study, a clear pattern emerged. In varieties where specific gravity of the entire tuber was high there was a large difference in spcific gravity between zone three (pith) and the two outer zones. In varieties with low specific gravity this difference was comparatively small. There was generally little difference in specific gravity between zones one and two. Specific gravity of zone three was relatively uniform between varieties.

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2. East, E. M. 1908. The study of the factors influencing the improvement of the potato. Ill. Agr. Exp. Sta. Bull. 127.
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5. Johnson, T. and C. Boyle. 19119. Observations on the industrial and nutritive value of potato in Ireland. Jour. Dept. Agr. Ire. 19: 416-429.
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NEWS AND REVIEWS

LIST OF INTERNATIONAL POTATO RESEARCH PROJECTS[1]

POTATO ASSOCIATION OF AMERICA

INTERNATIONAL RELATIONS COMMITTEE 1958[2]

This compilation, compiled at the request of many members of the International Relations Committee[3], contains a list of institutions or laboratories and the potato research programs under way at each, the project leaders and their affiliations. Most laboratories and individuals contacted have sent replies, though some, unfortunately, did not. Any additional institutions, laboratories or individuals wishing to be added to a supplement list are asked to submit the required information.

It is hoped that good use will be made of this information, and that it will help to develop a mutual understanding of the major problems confronting the different countries, and establish carefully planned international cooperation aimed at specific objectives.

Since the list is undoubtedly incomplete, with some errors, it will be appreciated if corrections or additions, along with changes in address or activities, are reported without delay.

The committee wishes to thank all individuals who contributed the information included in this compilation.

UNITED STATES
F. D. Cochran, D. S. Correll, C. W. Frutchey, R. H. Larson and Ora Smith,* Chairman.
**Liaison Officer with European Potato Association.*

CANADA
D. S. MacLachlan and L. C. Young.

CENTRAL AND SOUTH AMERICA
E. H. Casseres, J. Cervantes, N. Estrada, A. B. Montaldo, Carlos Ochoa, K. M. Silberschmidt and M. V. Fernandez Valiela.

EUROPE
Maria-Luise Baerecke, George Cockerham, J. G. Hawkes, C. Martin, J. Munster, A. Rozendaal and H. J. Toxopeus.

AFRICA

EGYPT

MINISTRY OF AGRICULTURE, DEPARTMENT OF PLANT PATHOLOGY, P. O. GIZA, EGYPT

Farid Nour-Eldin

VIRUS DISEASES — Virus A, X, and Y—hosts, properties, serology, strains, Leaf roll virus — hosts, strains, transmission.

Abd-El-Kader-M. El-Zarka

FUNGUS DISEASES — Late blight—pathogenicity, strains, control with chemicals, breeding for resistance.

Scab—disease control by green manures, resistance.

[1]This compilation does not include Canada or the United States.
[2]R.H. Larson, Chairman, Department of Plant Pathology, University of Wisconsin, Madison 6, Wisconsin.
[3]Potato Association of America, International Relations Committee of 1958

Soliman Sidky

FUNGUS DISEASES — Late and early blight—control measures, climatic conditions favoring field spread.

Scab—control by seed-disinfection; conditions favoring the field spread; strains; variety resistance.

MINISTRY OF AGRICULTURE, TRUCK CROP SECTION, P. O. DOKKY, EGYPT

M. S. Attia

FUNGUS DISEASES — Late blight—breeding for resistance.

Scab—breeding for resistance.

SOUTH AFRICA

DEPARTMENT OF AGRICULTURE, DIVISION OF PLANT PATHOLOGY, P. O. BOX 994, PRETORIA, SOUTH AFRICA

J. E. van der Plank

BREEDING — Resistance against *Phytophthora infestans,* leaf roll virus, viruses A, X and Y, internal tuber necrosis and scab.

(In collaboration with the College of Agriculture, Cedara, Natal, and the Agricultural Experiment Stations at Bethlehem, O.F.S., and George, C.P.)

ASIA

INDIA

DEPARTMENT OF AGRICULTURE, WEST BENGAL, WRITERS' BUILDINGS, CALCUTTA, INDIA

H. C. Choudhuri

BREEDING AND GENETICS — Disease and insect resistance. Genetics of flower color and agronomical characters.

FUNGUS DISEASES — *Phytophthora infestans*—genetics of resistance.

Alternaria solani—resistance.

GOVERNMENT COLLEGE, DEPARTMENT OF BOTANY, NAINI TAL U.P., INDIA

K. S. Bhargava

FUNGUS DISEASES — Early blight—epidemiology; late blight—epidemiology, strains.

VIRUS DISEASES — Virus X—hosts, strains; virus Y—hosts, strains; leaf roll virus—hosts, strains.

INDIAN AGRICULTURAL RESEARCH INSTITUTE, DIVISION OF MYCOLOGY & PLANT PATHOLOGY, NEW DELHI, INDIA

M. K. Hingorani

BACTERIAL DISEASES — Brown rot—presence of *Pseudomonas solanacearum* var *asiatica,* its strains, effect of environment.

Soft rot—comparative study of *Erwinia carotovora* and *E. atroseptica,* factors influencing the disease.

R. S. Vasudeva

FUNGUS DISEASES — Early blight—control of, assessment of losses.

VIRUS DISEASES — Potato virus X—strains, inhibition of viruses in potato sprouts.

UNIVERSITY OF ALLAHABAD, DEPARTMENT OF BOTANY, ALLAHABAD, INDIA

R. N. Tandon and G P. Agrawal

FUNGUS DISEASES — Pathological and physiological studies on *Fusarium coeruleum.*

ISRAEL

HEBREW UNIVERSITY, FACULTY OF AGRICULTURE, REHOBOT, ISRAEL

Nachum Kedar (Kammerman)

FUNGUS DISEASES — *Phytophthora infestans*—trials with resistant varieties. Resistance and activity of respiratory enzymes.

Nachum Kedar — J. Wahl

FUNGUS DISEASES — Biological races of *Phytophthora infestans* in Israel.

Sara Zimmerman-Gries

NONPARASITIC DISEASES — a) Second growth—control of tubers with second growth for sowing. b) Resistance to internal tuber necrosis.

VIRUS DISEASES — Field control of the spread of virus diseases.

JAPAN

HOKKAIDO AGRICULTURAL EXPERIMENT STATION, SHIMAMATSU POTATO BREEDING FARM, ENIWA-CHO, CHITOSE-GUN, HOKKAIDO, JAPAN

T. Nagata

BREEDING — Crossability of wild species to cultivated potato. Disease resistance—late blight, virus.

BIOLOGICAL INSTITUTE, UTSUNOMIYA UNIVERSITY, UTSUNOMIYA, TOCHIGI, JAPAN

S. Okuno

BREEDING — Genetics—frost resistance, maturity.

TAXONOMY — Cytological behavior of species hybrids.

CENTRAL POTATO FOUNDATION STOCK FARM, HIROSHIMA-MURA, SAPPORO-GUN, HOKKAIDO

R. Sato

FUNGUS DISEASES — Silver scurf—varietal resistance.

HIROSHIMA AGRICULTURAL EXPERIMENT STATION, ENTOMOLOGY, SAIZYO, HIROSHIMA

T. Miyake

INSECTS — Tuber moth control.

HOKKAIDO NATIONAL AGRICULTURAL EXPERIMENT STATION, SAPPORO, JAPAN

DEPARTMENT OF ENTOMOLOGY

K. Sakurai

INSECTS — Wire worm control — mole cricket control.

DEPARTMENT OF FIELD CROPS

H. Yumura

PHYSIOLOGY — Storage.

DEPARTMENT OF PLANT PATHOLOGY

T. Narita

BACTERIAL DISEASES — Bacterial wilt, ring rot.

FUNGUS DISEASES — Powdery scab.

N. Oshima

VIRUS DISEASES — Virus X—symptoms, host; virus G—symptoms; witches'-broom—symptoms, hosts, transmission; purple top—identification.

I. Tanaka

FUNGUS DISEASES — Late blight—chemical control.

K. Tomiyama

FUNGUS DISEASES — (Cooperative workers: R. Sakai, N. Takase and R. Takakuwa) Late blight—resistance, pathological physiology, physiology and races of pathogen.

HOKKAIDO UNIVERSITY, FACULTY OF AGRICULTURE, SAPPORO, JAPAN

DEPARTMENT OF CROP SCIENCE

Keisaku Taguchi

BREEDING — Varietal hybridization: experiments concerning the floral organs, degrees of environmental deviation of the main characters, expression of characters and their probability of selection in the breeding process. Interspecific hybridization. Characters of *Solanum* species. Breeding value of the wild types. Cytogenetical studies on the polyploid and haploid plants of *Solanum* species, and breeding value. (Associated with H. Kurihara, K. Tabata, and Y. Irikura — Tohoku National Agricultural Experiment Station, Morioka, Japan).

PHYSIOLOGY — Studies of the sprouting nature of potato. (Associated with T. Takahashi, Agronomy or Crop Science, University of Hokkaido).

DEPARTMENT OF PLANT PATHOLOGY

T. Fukushi

VIRUS DISEASES — Potato witches'-broom — insect vector, and host range. Virus X—electron microscope studies.

D. Murayama

VIRUS DISEASES — Virus X and Y serology, inactivation.

T. Ui

FUNGUS DISEASES — Powdery scab—host range.

DEPARTMENT OF PLANT PHYSIOLOGY

T. Tagawa

PHYSIOLOGY — Tuberization.

HYOGO AGRICULTURAL COLLEGE, SASAYAMA, HYOGO, JAPAN.

DEPARTMENT OF FIELD CROPS

K. Kawakami

PHYSIOLOGY — Dormancy and vigor of seed tuber.

LABORATORY OF PLANT BREEDING

K. Kawakami

BREEDING — Dormancy and earliness; late blight—resistance.

PHYSIOLOGY — Rest period of seed tubers.

M. Matsubayashi

BREEDING — Inheritance of economic characters in wild species, and incorporating into commercial varieties.

TAXONOMY — a) Species differentiation (cytogenetic interrelationships among the tuberous *Solanum* species).

b) Origin of polyploid species (especially *Solanum tuberosum*)

c) Detection of basic chromosome number.

KYUSHU UNIVERSITY, FACULTY OF AGRICULTURE, FUKUOKA, JAPAN

H. Yoshii

FUNGUS DISEASES — Early blight—pathogenicity, strains; rhizoctonia—pathogenicity, strains.

VIRUS DISEASES — Virus X—strains, resistance; virus Y—hosts, strains, resistance.

MIYAGI AGRICULTURAL EXPERIMENT STATION, DEPARTMENT OF PLANT PATHOLOGY, SENDAI, JAPAN

Y. Sakurai

FUNGUS DISEASES — Late blight—disease cycle, control.

MIYAZAKI AGRICULTURAL EXPERIMENT STATION, DEPARTMENT OF PLANT PATHOLOGY AND ENTOMOLOGY, MIYAZAKI, JAPAN

S. Goto

NEMATODES — Tuber rot.

NAGASAKI AGRICULTURAL EXPERIMENT STATION, POTATO BREEDING FARM, AINO, NAGASAKI, JAPAN

K. Miyamoto

BREEDING.

NAGOYA UNIVERSITY, PLANT PATHOLOGY, ANZYO, AICHI-KEN, JAPAN

Tokuzo Hirai

FUNGUS DISEASES — Late blight—resistance of tubers.

VIRUS DISEASES — Virus X—virus multiplication in host cells.

Virus Y—strains and resistance.

Leaf roll virus—diagnosis.

NATIONAL INSTITUTE OF AGRICULTURAL SCIENCES, DEPARTMENT OF PLANT PATHOLOGY, KITA-KU, TOKYO, JAPAN.

H. Mukoo

BACTERIAL DISEASES — Ring rot.

SHIMANE AGRICULTURAL COLLEGE, DEPARTMENT OF PLANT PATHOLOGY, MATSUE, SHIMANE, JAPAN.

M. Yamamoto

FUNGUS DISEASES — Late blight—resistance, pathological physiology.

TOHOKU NATIONAL AGRICULTURAL EXPERIMENT STATION, MORIOKA, JAPAN

DEPARTMENT OF FIELD CROPS

K. Oizumi

PHYSIOLOGY.

DEPARTMENT OF GENETICS

H. Kurihara

BREEDING.

DEPARTMENT OF PLANT PATHOLOGY

K. Iida

FUNGUS DISEASES — Black scurf—varietal resistance (K. Kudo).

TOHOKU UNIVERSITY, FACULTY OF AGRICULTURE, DEPARTMENT OF PLANT PATHOLOGY, SENDAI, JAPAN

H. Tasugi

BACTERIAL DISEASES — Ring rot—control by heat treatment.
FUNGUS DISEASES — Late blight—physiology of pathogen (with T. Misawa).

TOKYO UNIVERSITY, BUNKYO-KU, FACULTY OF AGRICULTURE, DEPARTMENT OF PLANT PATHOLOGY, TOKYO, JAPAN

K. Yora—Cooperative workers—Y. Komuro and S. Okuyama

VIRUS DISEASES — Virus X—symptoms, strains, varietal resistance,
Virus Y—symptoms, strains, resistance,
Virus F—symptoms,
Leaf roll—tuber grafting,
Virus causing top necrosis—identification.

WEST PAKISTAN

DEPARTMENT OF PLANT PROTECTION, DIVISION OF PLANT PATHOLOGY, KARACHI, PAKISTAN

A. G. Kausar

FUNGUS DISEASES — Early blight—field trials of spray fungicides.

RESEARCH INSTITUTE, VEGETABLE SECTION, LYALLPUR, WEST PAKISTAN

Abdur Rashid Khan

BREEDING — Genetics and breeding behavior of certain species and intra specific hybrids, breeding varieties for agronomic characters and disease resistance.
PHYSIOLOGY — Nutrition—manurial requirements and responses.
AGRONOMY — Varieties—trial of local and foreign varieties, seed production in different regions.

AUSTRALIA - NEW ZEALAND

COMMONWEALTH SCIENTIFIC & INDUSTRIAL RESEARCH ORGANIZATION, DIVISION OF ENTOMOLOGY, BOX 109, CANBERRA, AUSTRALIA

N. E. Grylls

INSECTS — Virus vectors (mainly leafhoppers), viruses transmitted and host range.

VIRUS DISEASES — Big Bud — witches'-broom complex which includes Australian potato purple top wilt.

DIVISION OF PLANT INDUSTRY

K. O. Muller

BREEDING — Genetics — a) Action of genes controlling resistance to late blight (including chemistry of phyto-alexines).
b) Advising Australian Potato Breeders in breeding for disease resistance.

FUNGUS DISEASES — a) Late blight—field resistance.
b) *Pythium* spec.—host pathogen relationships on a cellular level.

DEPARTMENT OF AGRICULTURE, VICTORIA, BIOLOGY BRANCH, BURNLEY, E. 1, AUSTRALIA

R. D. Anderson

VIRUS DISEASES — Virus X—resistance, strain effect on yield serology.
Virus S—resistance, serology, isolation of virus S free clones.
Virus Y—resistance, vectors.
Purple Top Wilt Virus—hosts identification methods, vector S.

S. C. Chambers

FUNGUS DISEASES — Late blight—resistance and strain. Gangrene—properties and storage treatments.

D. E. Harrison

BACTERIAL DISEASES — Identification (morphology, physiology, pathogenicity and serology); varietal testing in glasshouse and field; field trials of bacterial wilt and blackleg.

FUNGUS DISEASES — Rhizoctonia—Field control by dipping and crop rotation. Scab—varietal testing and soil treatments.

NEMATODES — Root Knot—varietal testing; field control by soil sterilization and rotation.

DEPARTMENT OF AGRICULTURE, POTATO BRANCH, TREASURY PLACE, MELBOURNE, VICTORIA, AUSTRALIA

W. A. Downie

QUALITY — Physical quality as denoted by attributes of size of sample, Hollow Heart, etc. Cultural methods favoring germination, yield and physical quality.

STORAGE — Sprout inhibition.

POTATO RESEARCH STATION, HEALESVILLE, VICTORIA, AUSTRALIA

H. Swaan

BREEDING — Virus Y, virus X, late blight, bacterial wilt, blackleg, root knot —resistance.

UNIVERSITY OF ADELAIDE, WAITE RESEARCH INSTITUTE, ADELAIDE, SOUTH AUSTRALIA

Rupert J. Best

VIRUS DISEASES — The exchange of genetic determinants between strains of potato virus X; viral genetics at the chemical level.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, CHRISTCHURCH, NEW ZEALAND

CROP RESEARCH DIVISION

C. M. Driver and R. C. Close

BREEDING — *Resistance to late blight;
Resistance to early blight;
*Resistance to viruses X, Y, A, S, leaf roll
*Resistance to pink rot (*Phytophthora erythroseptica*);
Resistance to scab;
Breeding for yield, quality and absence of tuber defects.

FUNGUS DISEASES — Late blight—hosts, races, field resistance, testing methods; Scab—field control with therapeutants.

INSECTS — Aphid populations on potato crops.

NONPARASITIC DISEASES — Internal tuber necrosis. Hybrids grown in areas where necrosis is bad are selected for resistance. Information is being collected on conditions favoring necrosis.

QUALITY — Selection against growth cracks, hollow heart, second growth, and for cooking quality. Sprout control.

VIRUS DISEASES — *Virus X—hosts, strains, test plants, therapy (chemo-, thermo- and with ultraviolet light), spread, surveys, selection X-free stocks.
*Virus Y—hosts, strains, test plants, therapy (chemo-, thermo-, and with ultraviolet light), spread, selection of Y-free stocks, serology.
*Virus S—surveys, tests, therapy.
*Virus A—surveys, tests, therapy.
*Leaf roll virus—testing methods, spread.

*Major projects.

PLANT DISEASES DIVISION
H. C. Smith
FUNGUS DISEASES — Pink rot (*Phytophthora erythroseptica*)—Field control by chemical means.

CENTRAL AMERICA

COSTA RICA

INTER-AMERICAN INSTITUTE OF AGRICULTURAL SCIENCES, SAN JOSE, COSTA RICA
E. H. Casseres and Coto Monge Alvaro (Ministry of Agriculture)
BREEDING — a) Evaluation and multiplication of high yielding disease resistant (*P. infestans*) clones.
b) Development of seed production techniques in the tropics.

MINISTRY OF AGRICULTURE, SAN JOSE, COSTA RICA
C. A. Soto and Carlos Bianchini
FUNGUS DISEASES — Studies of chemical control of late blight.
Alvaro Coto and Mauro Molina
QUALITY — Fertilizers—phosphorus and other major elements.

GUATEMALA

SERVICIO COOPERATIVO INTERAMERICANO DE AGRICULTURA, LA AURORA, GUATEMALA
Marco A. Flores
FUNGUS DISEASES — Late blight—resistance to prevailing races in introduced potato varieties. Control by the use of fungicides.
INSECTS — Virus vectors.
VIRUS DISEASES — Leaf roll—control by systemic insecticides.

MEXICO

OFICINA DE ESTUDIOS ESPECIALES, S.A.G. (THE ROCKEFELLER FOUNDATION), CALLE LONDRES NO. 40, MEXICO 6, D. F. MEXICO
John S. Niederhauser, Javier Cervantes, and Jorge Galindo
BREEDING — Late blight—resistance.
FUNGUS DISEASES — Late blight—pathogenicity, strains, oospore formation.
TAXONOMY — Species collections and hybridization.
VIRUS DISEASES — Purple top—transmission, vectors.

EUROPE

AUSTRIA

FEDERAL INSTITUT FOR PLANT PROTECTION, WIEN (VIENNA) II, TRUNNERSTR. 5, AUSTRIA
Hans Wenzl
FUNGUS DISEASES — Late blight—field control.
NONPARASITIC DISEASES — Spindling sprout—diagnosis in unsprouted tubers.
VIRUS DISEASES — Stolbur virus—control, leaf roll virus—diagnosis by microscopic methods.

LANDWIRTSCHAFTLICH - CHEMISCHE BUNDESVERSUCHSANSTALT, PROMENADE 37, LINZ/DONAU, AUSTRIA
Josef Gusenleitner
INSECTS — Ecology of aphids in relation to virus spread.
NEMATODES — Spread of potato nematodes as influenced by soil nutrients.
VIRUS DISEASES — Development of methods for the rapid detection of viruses A, X, Y and leaf roll.

O. OE. LANDES - SAATBAUGENOSSENSCHAFT, KARTOFFELZUCHTSTATION KEFERMARKT, OBER-OOESTERREICH, AUSTRIA
Eugen Maierhofer
BREEDING — Genetics, disease resistance (*Phytophthora infestans*), general yield, starch yield — (Austria does not have any potato varieties of its own. Our most important problem at present is the breeding of new varieties)

PHYSIOLOGY — Influence of day length; uniformity of tuber formation as influenced by genetic and physiologic factors.
VIRUS DISEASES — Leaf roll, virus Y (especially the prevention of transfer of nonpersistent viruses).

BELGIUM

FONDS DE LA RECHERCHE SUR LA POMME DE TERRA, A LIBRAMONT (PROV. LUX.), BELGIUM

Valere Melard
BREEDING — Genetics, disease resistance.
FUNGUS DISEASES — Late blight.
NEMATODES — Resistance to golden nematode.
TAXONOMY — Species collections, species hybridization, cytogenetics.

STATION DE RECHERCHES DE L'ETAT POUR L' AMELIORATION DE LA CULTURE DE LA POMME DE TERRE, A LIBRAMONT (PROV. LUX.)

Leon Nys
QUALITY — Conservation — nutrition.
Nestor Rigot
BREEDING — Genetics, disease, insect and nematode resistance.
PHYSIOLOGY — Tuberization, nutrition.

STATION D'ENTOMOLOGIE DE L'ETAT, COUPURE LINKS, 233, GAND. BELGIUM

J. Van Den Brande
NEMATODES — Golden, resistance, method culture.

STATION DE PHYTOPATHOLOGIE, 8, RUE DU BORDIA, GEMBLOUX, BELGIUM

Georges Roland
INSECTS — Virus vectors.
VIRUS DISEASES — Viruses A, S, X, Y—hosts, properties, serology, strains, resistance.
Leaf roll—hosts, strains, resistance.

UNIVERSITE DE LOUVAIN, INSTITUT CARNOY, 24, RUE DU CANAL, LOUVAIN, BELGIUM

Andre Gilles
TAXONOMY — Species collections, species hybridization, mutations, polyploidy.

CZECHOSLOVAKIA

INSTITUTE FOR PLANT PROTECTION, CZECHOSLOVAK ACADEMY OF SCIENCES, PRAHA - RUZYNE, CZECHOSLOVAKIA

J. Dirlbeck
INSECTS — Potato beetle—biology.
E. Jermoljev
VIRUS DISEASES — Diagnoses of viruses. Physiology of the degeneration of potatoes (ecological and virus).
V. Koula
INSECTS — Potato beetle—chemical control.
H. Prusova
FUNGUS DISEASES — *Phytophthora infestans*—chemical control.
M. Stanek
FUNGUS DISEASES — Bacterial black stem of potatoes.
J. Zakopal
FUNGUS DISEASES — Wart—biology and soil disinfection.

INSTITUTE FOR VIROLOGY, CZECHOSLOVAK ACADEMY OF SCIENCES, MLYNSKA' DOLINA, BRATISLAVA 9, CZECHOSLOVAKIA

V. Valenta
VIRUS DISEASES — Stolbur virus—hosts, properties, vectors, strains; witches'-broom virus—hosts, properties, vectors, strains.

DENMARK

ROYAL AGRICULTURAL COLLEGE, ROLIGHEDSVEJ 23, COPENHAGEN V, DENMARK

DEPARTMENT OF PLANT PATHOLOGY

Aa. Hellmers

BACTERIAL DISEASES — Blackleg.

VIROLOGICAL LABORATORY

Henning P. Hansen

VIRUS DISEASES — Virus resistance, methods for testing and selection, preferentially concerning viruses X, Y, S, A and leaf roll.

POTATO BREEDING STATION, VANDEL, DENMARK

Borge Jacobsen

BREEDING — Genetics—resistance to late blight, scab.

QUALITY — Tuber rots.

STATE EXPERIMENT STATION, TYLSTRUP, DENMARK

T. Andersen, Director

BREEDING — Resistance to scab and late blight.

PHYSIOLOGY — Starch determination methods.

STATE EXPERIMENTAL STATION FOR PLANT DISEASES AND PESTS, LYNBGY, DENMARK

L. Hammarlund

FUNGUS DISEASES — Late blight control.

H. Ronde Kristensen

VIRUS DISEASES — Leaf roll, X, Y, S, internal rust spot.

H. Mygind

FUNGUS DISEASES — Testing of potato varieties for resistance to wart and scab.

A. Weber

PHYSIOLOGY — Magnesium deficiency.

STATENS FORSOGSSTATION, STUDSGAARD, DENMARK

Johs. Bak Henriksen

BACTERIAL DISEASES — Blackleg—influence of storage conditions of seed potatoes from different soil types.

FUNGUS DISEASES — Late blight—influence of late blight control and killing of haulm on storage.

Sv. E. Hansen

VIRUS DISEASES — Virus X—yield of X-free and X-infected potatoes, (different varieties and X-strains)

Virus S—diagnostic methods, (Antiserum and test plants)

Leaf roll—diagnostic methods, (Colour-tests, eyecork-growing in glasshouse in relation to different light sources).

Time for symptom development after infection — Yield of different clones of virus free potatoes.

ENGLAND - NORTHERN IRELAND - SCOTLAND

BIRMINGHAM UNIVERSITY, DEPARTMENT OF BOTANY, BIRMINGHAM, ENGLAND

G. P. Chapman (supervised by J. G. Hawkes)

Chromosome analyses at pachytene of *Solanum* species and hybrids.

Miss M. Hudson (supervised by J. G. Hawkes)

PHYSIOLOGY — Elucidation of the physiological basis and mode of inheritance of frost resistance in potatoes.

J. G. Hawkes

TAXONOMY — Taxonomic revision of wild and cultivated potato species. Elucidation of species relationships in *Solanums* by means of analyses of F_1 and F_2 hybrid progenies. Cytological analyses of species hybrids.

The study of relationships between *Solanum* species using plant immunological techniques (with G. P. Gell and S. T. Wright at Medical School, Birmingham University).

EAST MALLING RESEARCH STATION, PLANT PATHOLOGY, KENT, ENGLAND

A. F. Posnette

VIRUS DISEASES — Potato witches'-broom and Stolbur-like viruses—Leafhopper vectors and strain relationships to those causing diseases of fruit and hops.

MINISTRY OF AGRICULTURE, FISHERIES & FOOD, PLANT PATHOLOGY LABORATORY, HARPENDEN, HERTS, ENGLAND

M. Hollings

VIRUS DISEASES — Assessment of aphid activity and other factors influencing the spread of leaf roll and rugose mosaic in the field.

E. C. Large

FUNGUS DISEASES — Late blight—forecasting, loss estimations, epidemiology and control.
Common scab—Surveying and loss estimations.

NATIONAL INSTITUTE OF AGRICULTURAL BOTANY, HUNTINGTON ROAD, CAMBRIDGE, ENGLAND

E. Brown (Assistant for Propagations)

BREEDING — Clone selections.

J. C. Cullen (Head of Branch)

BREEDING — Adaptation of varieties and clones.

FUNGUS DISEASES — Field behavior of varieties.

QUALITY — Dry matter specific gravity and texture. Discoloration before and after cooking.

VIRUS DISEASES — Field behavior of varieties.

J. C. Hughes (Organic Chemist)

QUALITY — Chemistry of stem end blackening.

M. Kostrowicka (Assistant for Fungal Diseases)

FUNGUS DISEASES — Late blight—strains and resistance.
Rhizoctonia and common scab—resistance.

D. H. Long (Assistant for Trials)

PHYSIOLOGY—Varietal studies on sprouting.

D. E. Richardson

VIRUS DISEASES — Viruses X and S—serology resistance.
Virus Y—strain resistance.
Leaf roll—resistance.

PLANT BREEDING INSTITUTE, TRUMPINTON, CAMBRIDGE, ENGLAND

H. W. Howard

BREEDING — Genetics; disease resistance with particular reference to — Late blight, scab, wart, golden nematode, viruses A, X, Y, and leaf roll.

CYTOGENETICS — Chimaeras and related problems including skin color genetics.

ROTHAMSTED EXPERIMENTAL STATION, HARPENDEN, HERTS, ENGLAND

L. Broadbent

INSECTS — Aphid movement and virus spread.

VIRUS DISEASES — Virus Y and leaf roll—epiphytology and control of virus spread with insecticides.

J. M. Hirst

FUNGUS DISEASES — Late blight—overwintering, epidemiology, forecasting.

B. Kassanis

VIRUS DISEASES — Virus S—relationships between strains; elimination of the virus by a tissue culture method.
Virus F and G—relationships between them and their vector.
Two viruses (isolated from South American potato species)—properties.
Virus Y (an Indian strain)—properties.

D. H. Lapwood

FUNGUS DISEASES — Late blight—field resistance of potato varieties.

G. A. Salt

FUNGUS DISEASES — Skin-spot (*Oospora pustulans*)—biology and life-history, source, time and method of infection, relation between surface infection, eye infection and infection of roots and stolons.

Mrs. M. A. Watson

VIRUS DISEASES — Strains of potato virus Y, particularly potato virus C. The ability of PVC to be aphid-transmitted. Its possible origin from the parent strain and the connection between aphid-transmissibility and the ability systemically to invade Majestic and President potatoes.

THE QUEEN'S UNIVERSITY OF BELFAST, PLANT PATHOLOGY, NORTHERN IRELAND

A. E. Miskett and E. L. Calvert

FUNGUS DISEASES — Late blight—control, physiologic races, resistance.

Common scab, skin spot, dry rot, silver scurf, rhizoctonia—control by tuber disinfection.

VIRUS DISEASES — Virus X—serology, strains, resistance.

Virus Y—strains, resistance.

Virus S—hosts, serology, strains, resistance.

Viruses in general—propagation and building up of virus free stocks of commercial varieties.

DEPARTMENT OF AGRICULTURE FOR SCOTLAND, SCIENTIFIC SERVICES, EAST CRAIGS, CORSTORPHINE, EDINBURGH 12, SCOTLAND

W. P. L. Cameron

INSECTS — Aphis ecology in selected areas in relation to virus spread. Jassid collections for virus transmission studies.

D. C. Graham

BACTERIAL DISEASES — Blackleg and soft rot organisms—complete reassessment of its natural history and control, and development of varietal susceptibility tests.

J. L. Hardie

BREEDING — Seedling variety trials.

QUALITY — Quality assessment of new varieties.

TAXONOMY — Variety collections, disease and abnormal plant collections.

VIRUS DISEASES — Susceptibility tests of new varieties. Resistance trials with leaf roll and virus Y. Production of stocks free from leaf roll and viruses X, Y, and S.

T Mabbott

NEMATODES — Golden eelworm—strains ,embedded cysts, control by irradiation; viability of cysts and cyst natural history in the soil; tests of different soil sampling techniques.

J. M. Todd

FUNGUS DISEASES — *Phoma* spp. causing gangrene and skin necrosis of potatoes—pathogenicity strains, wild host range, serological aspects.

*Common scab—laboratory and glasshouse varietal susceptibillity test methods and viability after tuber treatment.

*Powdery scab and rhizoctonia scab—laboratory and glasshouse varietal susceptibility test methods and viability after tuber treatment.

*Shared with D. C. Graham.

VIRUS DISEASES (shared with D. C. Graham) — Viruses G, X, S, Y (+ veinal necrosis strain), leaf roll, witches'-broom, ring spot viruses, cucumber mosaic virus and others—serology, strains, means of spread, effect on yield, tuber infection diagnosis (leaf roll), vector and alternative hosts (witches'-broom)

NORTH OF SCOTLAND COLLEGE OF AGRICULTURE, ABERDEEN, SCOTLAND

Jean F. Malcolmson—Agricultural Research Council

Elizabeth G. Gray—Advisory Mycology

FUNGUS DISEASES — Gangrene—taxonomy of the causal *Phoma* species: factors affecting the disease occurrence and development of the disease: control.

Jean F. Malcolmson

BACTERIAL DISEASES — Blackleg and soft rot—taxonomy of the causal *Erwinia* and *Pseudomonas* species, factors affecting disease occurrence and development, role of the organisms in the soil flora.

UNIVERSITY OF ABERDEEN, DEPARTMENT OF BACTERIOLOGY, ABERDEEN, SCOTLAND

Alan M. Paton

BACTERIAL DISEASES — Blackleg and soft-rot—taxonomy of the causal *Pseudomonas* species, factors affecting disease occurrence and development.

SCOTTISH HORTICULTURAL RESEARCH INSTITUTE, DEPARTMENT OF PLANT PATHOLOGY, MYLNEFIELD, INVERGOWRIE, BY DUNDEE, SCOTLAND

C. H. Cadman and B. D. Harrison

VIRUS DISEASES — Leaf roll virus—vector relations, strains, varietal susceptibility, field spread.
Virus Y—strains, field spread.
Ring necrosis virus—properties, serology, mode of transmission.
Sugar beet ringspot virus—properties, serology, mode of transmission.
Other soil-borne viruses—properties, serology, mode of transmission.

A. G. Fisken

INSECTS — Biology of aphids in relation to spread of potato viruses in eastern Scotland.

SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING, SCOTTISH PLANT BREEDING STATION, PENTLANDFIELD, ROSLIN, MIDLOTHIAN, SCOTLAND

W. Black—Associate J. M. Dunnett

BREEDING — Co-ordinated breeding programme for the production of disease resistant economic varieties.
Genetics of resistance to late blight and the golden nematode.

FUNGUS DISEASES — Late blight—physiological races, pathogenicity.

NEMATODES — Golden nematodes—variation, pathogenicity.

G. Cockerham—Associates—D. A. Govier, A. W. Macarthur

BREEDING — Resistance to viruses X, A, Y, S, leaf roll—genetics of virus resistance.

VIRUS DISEASES — Virus X, A, Y, S, leaf roll—genetics of virus resistance. witches'-broom—hosts, vectors.

FINLAND

AGRICULTURAL RESEARCH CENTER, TIKKURILA, FINLAND

DEPARTMENT OF PEST INVESTIGATION

Veikko Kanervo

INSECTS — Distribution and importance of aphids transmitting virus diseases.

NEMATODES — Distribution of the golden nematode in Finland.

DEPARTMENT OF PLANT PATHOLOGY

E. A. Jamalainen

FUNGUS DISEASES — *Phytophthora infestans*—control by chemicals.
Scab (*Actinomyces* sp.)—control by chemicals.

VIRUS DISEASES — Virus X, S, Y and A—hosts, serology, occurrence and resistance.

AGRICULTURAL RESEARCH CENTRE, DEPARTMENT OF PLANT BREEDING, JOKIOINEN, FINLAND

Onni K. O. Pohjanheimo

BREEDING — Genetics—frost resistance, practical breeding and disease.
FUNGUS DISEASES — Early blight and late blight.
QUALITY — Starch content, cooking quality.

HANKKIJA EXPERIMENTAL FARM, HYRYLA, FINLAND

Eero Varis

BREEDING — Breeding of yellow-fleshed potatoes of good cooking quality. Field resistance of following diseases is examined:

a) Wart (controlled by Department of Plant Pathology, Agricultural Research Centre).
b) Late blight, especially in tubers (laboratory test).
c) Blackleg.
d) Viruses X, Y and S—serological tests.
e) Frost resistance.

UNIVERSITY OF HELSINKI, DEPARTMENT OF PLANT PATH OLOGY, VIIK, MAIMI, FINLAND

S. Antila

PHYSIOLOGY — Physiology of the resistance of potato plant to damage by freezing.

K. Laurila

FUNGUS DISEASES — *Phytophthora infestans*—overwintering of the fungus.

O. Pohjakallio

BREEDING — Genetics—appearance of somatic mutations in *Solanum tuberosum* and *S. demissum* crosses (with K. Multamaki, Plant Breeding Institute, Jokioinen, Finland).

PHYSIOLOGY — Light biology of the potato plant.

VIRUS DISEASES — The study of an unknown virus, which accelerates the development of some clones from the crossing *S. demissum* x *S. tuberosum*.

FRANCE

INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE, STATION CENTRALE DE PATHOLOGIE VEGETALE, ROUTE DE ST. CYR, VERSAILLES (S et O), FRANCE

Claude Martin

VIRUS DISEASES — Virus A, X, Y, leaf roll—comparative biochemistry of healthy and diseased plants (Enzymes, phenols, anthocyanines in relation with virus syntheses). Chemical diagnosis of viruses. Biochemical aspects of resistance to virus diseases.

INSTITUT PASTEUR, SERVICE DE PHYSIOLOGIC VEGETALE ET MYCOLOGIE, PARIS 15, FRANCE

G. L. J. Segretain

BREEDING — Genetics—seed selection.

PHYSIOLOGY — Tuberization—influence of symbiosis.

VIRUS DISEASES — Control of leaf roll, virus X, virus Y.

UNIVERSITE DE TOULOUSE, FACULTE DES SCIENCES, PLANT PHYSIOLOGY, TOULOUSE (HTE GARONNE), FRANCE

Jean Pavillard

PHYSIOLOGY — Growth and dormancy, influence of chemicals. Auxins oxidases and their role in physiology of the tuber. SH groups and their role in the physiology of growth. Scopoletine and other flowering hormones. Grafts and tissue culture.

VIRUS DISEASES — Virus X, leaf roll, double streak—influence of these viruses on potato physiology and application of these studies to early detection of the diseases. Effect of chemicals on virus multiplication *in vivo*.

EASTERN GERMANY - GERMAN FEDERAL REPUBLIC

BIOLOGISCHE ZENTRALANSTALT, INSTITUT FUER PHYTOPATHOLOGIE, ERMSLEBENERSTR. 52, ASCHERSLEBEN, EASTERN GERMANY

DEPARTMENT OF ENTOMOLOGY

H. W. Nolte

NEMATODES — Potato nematode (*Heterodera rostochiensis*)—activation processes, protection.

DEPARTMENT OF MICROBIOLOGY
G. M. Hoffman
FUNGUS DISEASES — Potato scab (*Streptomyces scabies*)—importance and pathogenicity of different strains, resistance of varieties, nutritional physiology.

DEPARTMENT OF VIRUS RESEARCH
M. Klinkowski and K. Schmelzer
VIRUS DISEASES — Relationships between the viruses of tomato Stolbur, tomato big bud, cranberry false blossom and potato witches'-broom.
K. Schmelzer
VIRUS DISEASES — Therapy of virus diseased tubers by meristem culture.

DEUTSCHE AKADEMIE DER LANDWIRTSCHAFTSWISSENSCHAFTEN ZU BERLIN, BIOLOGISCHE ZENTRALANSTALT BERLIN, KLEINMACHNOW BEI BERLIN, STAHNSDORFER DAMM 81, STAHNSDORF, KRS. POTSDAM, EASTERN GERMANY
H. Fischer
FUNGUS DISEASES — *Spongospora subterranea*—detection methods for use in quarantine.
INSECTS — *Phthorimaea operculella*—detection methods for use in quarantine.
W. Gottschling
VIRUS DISEASES — Tests for resistance.
FUNGUS DISEASES — *Synchytrium endobioticum*—tests for resistance.
Streptomyces scabies—tests for resistance.
Spongospora subterranea—tests for resistance.
J. Hartisch
VIRUS DISEASES — Metabolic physiology.
A. Hey
VIRUS DISEASES — Etiology, ecology, vectors.
FUNGUS DISEASES — *Synchytrium endobioticum*—biology, protection.
NEMATODES — *Heterodera rostochiensis*—ecology, population dynamics, protection.
J. Kradel
NEMATODES — *Heterodera rostochiensis*—biology, ecology, population dynamics, protection.
E. Schwartz
INSECTS — *Leptinotarsa decemlineata*—chemical protection.

FRIEDRICH- SCHILLER-UNIVERSITAET, INSTITUT FUER PHYTOPATHOLOGIE, JENA, EASTERN GERMANY
Gerhard Staar
NEMATODES — Races, stimulation-physiology, development and behavior in the soil — (Assistant H. Rode)
Diagnosis of life cycle — (Assistant R. Wabnitz)
VIRUS DISEASES — Endogenous virus development — (Assistant Miss L. Vogler)
Artificial virus synthesis "virogenesis" — (Assistant E. Vorsatz)

INSTITUT FUER PHYTOPATHOLOGIE, WIEBENFELSERSTR. 57A, NAUMBURG/SAALE, GERMANY
O. Henke
VIRUS DISEASES — Leaf roll virus—host metabolism.

UNIVERSITY OF HALLE, PHYTOPATHOLOGICAL INSTITUT, HALLE, EASTERN GERMANY
Ch. Schade
VIRUS DISEASES — Virus X and S—serology

BAYER. LANDESSAATZUCHTANSTALT, WEIHENSTEPHAN IN FREISING BEI MUENCHEN, GERMAN FEDERAL REPUBLIC
B. Arenz
BREEDING — Genetics—yield, quality, resistance to virus diseases (leaf roll, X, Y), late blight, nematodes.
INSECTS — Foliage—resistance, virus vectors.
PHYSIOLOGY — Nutrition.
VIRUS DISEASES — Leaf roll, X, Y, ringspot (Bukett), serology.

BIOLOGISCHE BUNDESANSTALT
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INSTITUT FUER LANDW. VIRUSFORSCHUNG, B. B. A.

VIRUS DISEASES

J. Brandes — European potato viruses—electron microscopy of European potato viruses.

O. Bode — European potato viruses—strain diagnosis, morphology, hosts and resistance.

H. L. Paul — European potato viruses—physiological-chemical investigations, quantitative virus essay.

J. Volk — European potato viruses—vectors and transmission.

INSTITUT FUER PHYSIOLOGISCHE BOTANIK, B. B. A.

FUNGUS DISEASES

J. Ullrich — a) *Synchytrium endobioticum*—physiological specialization, resistance tests, biology and process of infection.

b) *Phytophthora infestans*—biology and epidemiology, warning service and forecast.

INSTITUT FUER VIRUSSEROLOGIE, B. B. A.

VIRUS DISEASES

R. Bartels — Virus Y—strains, serology, test in potatoes, virus A—strains, serology, test in potatoes.

R. Bercks — Virus X—properties, serology, strains, test in potatoes, Bukett- and Pseudo-Aucuba-virus (related to tobacco ring-spot)—properties, serology, strains.

C. Wetter — Virus S—serology, strains, properties, heat-therapy of rod-shaped viruses.

BIOLOGISCHE BUNDESANSTALT, KOENIGIN LUISESTR. 19, BERLIN-DAHLEM, GERMAN FEDERAL REPUBLIC

K. Heinze

INSECTS — Vectors of potato virus diseases. Mode of transmission of persistent and nonpersistent viruses. Bionomics of vector species.

INSTITUT FUER HACKFRUCHTBAU, BIOLOGISCHE BUNDESANSTALT, GREVENERSTR. 297, MUNSTER/WESTF., GERMAN FEDERAL REPUBLIC

H. Goffart

NEMATODES — Resistance and control measures—golden, root knot, tuber rot.

Saprozoic nematodes.

INSTITUT FUER PFLANZENBAU UND SAATGUTERZEUGUNG, BRAUNSCHWEIG - VLKENRODE, GERMAN FEDERAL REPUBLIC

O. Fischnich and Chr. Patzold

PHYSIOLOGY — Influence of chemical and physical methods on tuber sprouting and plant growth (X-rays - gamma rays).

H. Krug

PHYSIOLOGY — Photoperiodical behavior.

JUSTUS LIEBIG-UNIVERSITAET, INSTITUT FUER PHYTOPATHOLOGIE, LUDWIGSTR. 23, GIESSEN/LAHN, GERMAN FEDERAL REPUBLIC

E. Brandenburg

VIRUS DISEASES — The "Eisenfleckigkeit-Pfropfenbildung" (Internal rust spot or Sprain-Spraing).

a) Distribution of the rattle-virus or other "soil-borne" viruses in fields where "Eisenfleckigkeit" is spread.

b) Infection by means of virus isolates or strains in the production of tuber symptoms.

c) Field susceptibility of German potato varieties.

[*To be continued in the January issue*]

CALIFORNIA TEST SHOWS EFFECTIVENESS OF FLOOR PADS

The University of California in cooperation with USDA, conducted shipping tests to determine the effectiveness of set types of floor pads currently used for preventing injury to potatoes in transit. A check treatment in which no pads were used was also included. The test was made on 14 rail shipments of White Rose potatoes shipped to Chicago and Detroit. The results of the tests are shown below and in addition to showing the effectiveness of each type of floor pad should convince every shipper of the value of floor pads.

Floor Padding[1]	Serious Injury[2] Lb./Cwt.	Floor Padding[1]	Serious Injury[2] Lb./Cwt.
Excelsior	1.9	Single-faced Corrugated strip	4.1
Shredded paper pad	3.6	Kraft strip	5.1
Fluted pad	5.1	None	8.8
Fiberboard pad	4.2		

LSD—5 per cent level 1.2
LSD—1 per cent level 1.6

[1]Nos. 1, 2, 3, and 4 are individual-sack pads. Nos. 5 and 6 are continuous car-length strips.
[2]Severely bruised and cut and crushed potatoes in bottom layer of load.

On the basis of the data obtained, cooling rates and subsequent transit temperatures could not be correlated with pad type. Cooling rates and transit temperatures in all four types of the test cars were within a safe range for potatoes. Each of the six types of floor pads tested materially reduced the amount of transit injury to potatoes in the bottom layer of the load in comparison to the check treatment, thus emphasizing the importance of protecting bagged potatoes from direct contact with the bare floor racks. In this test the excelsior pad provided significantly more protection than any of the other pads, probably because of its greater thickness and resiliency.

Based on the initial and final positions of the test bags, no relation was observed between pad type and load shifting.

No consistent differences in transit temperatures were observed between potatoes shipped on individual-sack pads and those shipped on continuous-strip type pads. under similar icing services, adequate refrigeration was obtained on both types of pads.

—*Reprinted from "The Valley Potato Grower", September, 1958*

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Author and Title Index

Subject Index

*Increase page numbers in May issue by 100.

A complete mimeographed list of the membership of the Potato Association of America is available from the treasurer to all regular members of the Association. The list is not available to firms wishing to use it for business purposes. The cost is 25¢ per copy.

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1958

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MACHINERY and EQUIPMENT ISSUE

PUBLISHED BY
THE POTATO ASSOCIATION OF AMERICA
NEW BRUNSWICK, NEW JERSEY
Volume III

Including
BUYER'S GUIDE
for Potato Growers

1958

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Associate Editor and Advertising Manager

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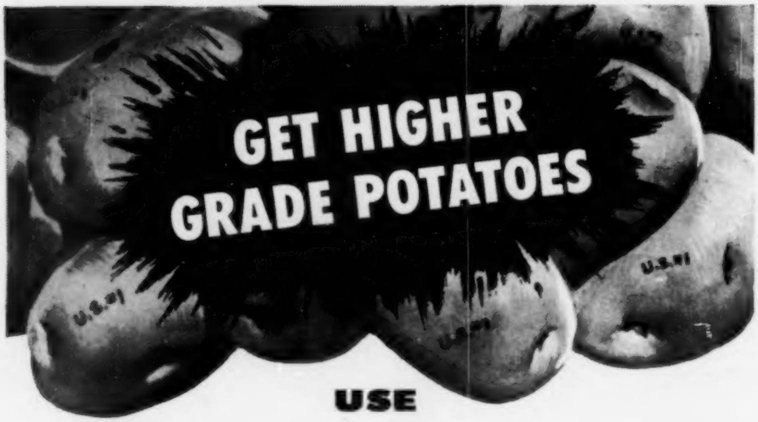
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Operating Suggestions for Mechanical Potato Harvesters

By A. H. Glaves

EVERY NEW OPERATOR of a mechanical potato harvester needs a combination of first hand experience combined with guidance drawn from the experience of others. Printed material or verbal instruction in unlimited quantity can not be substituted for actual experience in operating and managing any of these commercially manufactured potato harvesters now available. As in many other cases, *there is no substitute for experience.*

One of the objectives of my visit here today is to pass along to you a condensation of some of our experiences with mechanical potato harvesters during the last five years. This includes experience and observations chiefly in the Red River Valley area in Minnesota and North Dakota where there are now estimated to be between 400 and 500 commercially built machines. It also includes observations in Arizona, California, Alabama and Florida.

Another objective is to learn more of your requirements in this area and gain as much as possible from your experiences here.

Some questions and answers, seem to be a good way to exchange these experiences with you.

What can an operator with a new potato harvester do to get off to a good start with the operation? He should get delivery of the equipment two or three weeks before harvest must begin. Then, as early as possible, trial runs should be made with a skeleton crew to provide opportunity for minor adjustments and some experimenting with apron speeds and agitation to suit field conditions. The crew should work as a team and it needs practice before the stress of full speed operations. The skill of the operator, the capacity of the machine and the quaitly of work done by a green crew should increase with each day's work during the first week of operation and continue to improve through the second and third week.

Some Precautions

What specific precautions before harvest will contribute to most satisfactory results? Avoid packing of soil and the production of clods by preharvest field operations. Chemical or mechanical treatments to kill the vines and induce greater tuber maturity have become increasingly needed since the advent of improved insecticides and fungicides. These insecticide and fungicide materials help to keep the vines green and productive much later in the season, delaying the development of tuber maturity. Preharvest vine reduction with either vine beaters or pullers, which reduce the vines to small pieces, reduces mechanical interference and is helpful to either hand harvesting or mechanical harvesting but any preharvest field operations with heavy equipment when soils are wet can greatly increase clod problems. The control of tuber size by vine killing (either chemically or by mechanical mutilation) may be an important factor affecting skinning and bruising. Always remember two effects of extra size. The bigger they are the harder

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they fall every time they are dropped. And, especially with the more nearly round varieties, the larger the tubers the greater the tendency for rollback on either digger or harvester aprons. Failure to apply measures for size control early enough in the season demands more care and skill in the operator of a digger or harvester to maintain quality. It may be necessary to use less agitation, accept more tare in the loads, do more hand sorting or sacrifice quality of the product.

How should completeness of recovery, and quality of work done with full mechanization, compare with hand picking and complementary methods of handling? This depends a great deal on the interest of the machine operator in a quality job. High capacity or large volume should receive second consideration except when nearing the end of the season and there is probability of freezing weather. More maturity in the tubers at the end of the season should help toward higher harvesting rates without excessive injury. Under a wide range of conditions both completeness of recovery (potatoes not picked up) and quality of potatoes hauled from the field (with respect to mechanical damage) should be at least as good or generally better than with hand pickers working under similar conditions. Under adverse wet and trashy field conditions, and sometimes in cloddy conditions, the mechanical harvesters, with skilled operation, should attain more complete recovery and often smaller damage losses. There may be some exceptions to this in very stony conditions.

What about savings in labor and total harvesting costs? Labor savings often range from 50% to 75% over a wide range in field conditions. Labor savings are greatest where field conditions are most favorable. An important point is that the arduous nature of labor, stooping and heavy lifting, is practically eliminated. Part of the savings in labor costs are absorbed by increased machine costs but a net savings in total costs may still leave a net saving of 40% to 50% in total harvesting costs. Local labor supply and wage rates are strong factors in total cost comparisons.

For greatest savings, both in total harvesting costs and arduousness of labor, bulk handling has been combined with mechanical harvesting.

For many growers the combination of mechanical harvesting with bulk handling from field to storage or packing house has resulted in greater savings than by any other system yet widely used.

What are some pointers and suggestions which will help a new operator to gain proficiency? These will be given in condensed form in their natural sequence. Their order of importance will vary with different field conditions.

1. A good job must begin with accurate depth control of either digger or harvester blades. This aids good separation without excessive agitation or excessive cutting of tubers. Proper depth control is more easily attained where the soil lifting force is carried on caster wheels or spool shaped ridge wheels just ahead of the blade point. If the "suck" of the blade is carried on the tractor drawbar the flexing of the drawbar, the digger frame, or the flattening of the tractor tires due to weight transfer, especially in heavy soils, may indicate the need for stiffening drawbar, stiffening frame members and higher air pressure in the tractor tires, or the use of some type of gage wheels, before even an expert operator can control blade depth evenly. Inadequate blade control and irregular response to the action of the operator may alternately increase cuts, or overload the apron and reduce machine capacity as much as 30% to 40%.

2. *Blade shape and area* must be adapted to tillage practices prior to

harvest and to soil type. A tendency for sluggish scouring has been observed to result in spill-out at the sides of the blade causing losses of 15 bushels per acre or more which are not easily noticed. Smaller blade area in contact with the soil improves its scouring characteristics.

3. *Two stage or indirect operation* is being used by a large number of growers. This method involves the first operation of digging and windrowing, with a variable interval before the second operation, that of picking up and loading by a harvester with windrow retainer plates but no blade. This indirect method has been used with harvesters built for two-row direct operation as well as one-row direct machines. Indirect operation increases the capacity of the machine for soil separation with a minimum of agitation. Because it is a two-stage operation it involves the problem of coordination, therefore it *is not as simple and as easily managed as the direct method.* Its chief merits are that: (1) a lighter weight more simply designed harvester can be given two-row capacity and, (2) it is often preferred for its cleaner work under very adverse weedy or wet heavy soil conditions.

4. Windrowing for indirect harvesting has been done mostly with rather improvised modifications in standard makes of 2-row diggers. Frequently, *with the indirect method of operation, much more damage has been done in the windrowing operation than the total for pick-up, elevation, harvester separation and loading. We know now that this need not continue.* Improved windrowing equipment should become more widely available. A well laid narrow windrow, not more than 22 inches wide, of potatoes with very little damage is possible and is an important step toward highly satisfactory indirect harvesting.

5. *"Undersweep"* is a descriptive term applied to the soil which is sifted through the harvester apron at the front and dragged forward by the lower side of the apron. *It is important to understand this action and take full advantage of it,* in either digger or harvester operation, whether the operation is direct or indirect. By taking full advantage of the undersweep action, potatoes lying in loose soil in a windrow can be lifted very gently on to a harvester elevator apron (without a blade). The amount of undersweep tends to vary with soil conditions. It tends to increase as the apron wears. As link pitch increases more material falls through. As apron link wear increases the link pitch this also increases total apron length and both tend to increase undersweep. Undersweep can be reduced by removing apron links or otherwise regulated by changing the position of the lower supporting rollers under the front end of the apron to regulate the amount of sag at the front, which drags the sifted soil forward. Some, but relatively few production machines are provided with this adjustment.

6. Soil load and apron agitation on diggers and harvesters have been widely discussed, and are too involved for much discussion at this time. *It is generally agreed that the amount of agitation used should be so limited that some soil will be carried to a point above the last pair of agitators.* With some harvesters it is sometimes recommended that considerable soil be carried on the first apron to minimize rollback and to help pad the drop on to the next conveyor.

The possibilities of higher apron speeds combined with low magnitude high-frequency agitation are being explored. We have no specific recommendations on these possibilities at present.

7. There have been many recommendations for the rubberization of apron rods. *Rubberization does reduce damage to tubers but, unless apron link pitch is also increased soil separating capacity is diminished. Suitable*

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sprockets for wider pitches and interchangeable wider pitch aprons have not been generally available. This has limited the adoption of recommendations for the use of rubber covered links.

8. Wider pitch aprons are more suitable for round shaped tubers or large sizes of other shapes. The long or thin flat shaped varieties are not so well adapted to mechanized harvesting and handling in its present state of development.

9. Several machines now have separating conveyors with various tilt adjustments which can be changed in accord with prevailing conditions. Tilted belts incorporated in some harvester designs require somewhat less lateral tilt to induce separation by lateral roll than rubber covered rod aprons.

10. *Independent power on the harvester* is generally preferable to power take-off driven machines, especially under difficult conditions or where maximum operating capacity is important. With an independently powered harvester the travel speed can be varied in small increments without changing from an optimum apron speed. Or, in the more difficult spots apron speeds can be increased slightly while travel speed is reduced to thin out the flow of material to be separated. Independently and instantly variable speeds help attain maximum capacity with minimum tuber injury. Some experimenting with different combinations of apron speeds and travel speeds will be necessary for a new operator to adjust to different field conditions. A travel speed of about 1½ miles per hour, an apron speed 5% to 10% greater and combined with mild agitation, can be a good starting point.

11. Efficiency in hand sorting can often be improved by proper coaching and practice. *It has been demonstrated that hand sorting of materials carried on a conveyor in front of the workers is more efficiently done by workers tossing materials to the opposite* side of the conveyor *than if it is tossed behind* the workers. Soft clods can often be eliminated by pressing through a rod apron instead of tossing it elsewhere.

12. *Communication between the harvester operator, the tractor driver and the driver of the truck* being loaded *should be by simple and easily understood signals.* Hand signals seem to be very effective and are practical. The harvester operator should be located with all controls within easy reach and in a good position to make all necessary observations and he should be in command of maneuvers. It is good practice to begin filling a truck box about two thirds of the way forward and to the right of center, to work fore and aft evenly, and complete filling from the off side to near side.

Heavy log chains have been used to limit travel between truck and harvester to protect the harvester bulk loader against damage due to lack of coordination between drivers. Tractor and truck drivers should keep on the alert for visible signals from the harvester operator. When the truck is nearly loaded the tractor driver should be especially alert to truck stalling. Many operators select a truck driver to drive all trucks while being loaded so that it is necessary to train only one truck driver to respond to the operators signals and coordinate the truck speed with the harvester movement.

13. Special equipment features more or less necessary or very desirable for best operation are:

(1) Auxiliary truck transmissions or very low gear ratio to provide travel speeds as low as 2 miles per hour.

(2) Power steering devices for main wheels of the harvester or in the hitch arrangement. One or the other of these is a practical necessity for hillside oper-

ation, contoured rows of small fields.

(3) Live hydraulic power system for harvester controls, especially the bulk loader controls.

14. *Auxiliary cleaning equipment at the warehouse* is greatly depended upon by some growers. These are generally a part of the conveying equipment, which may be belt or apron conveyors. Under severely cloddy conditions many clods are crushed in the load and are readily screened out in the unloading operation. Some additional hand sorting at the unloading point is generally possible or can be provided if needed.

15. *Bulk hauling may be done in tilting dump truck boxes, hopper-conveyor type truck boxes or with either of these types on trailers.* The conveyor type boxes are preferable under adverse conditions or when soil separation on the harvester is deficient. When equipped with wide unloading gates and suitable companion equipment for unloading, dump boxes have satisfactorily handled dry and relatively clean potatoes.

16. *Large boxes* (approximately 4'x4'x4') designed for handling with power fork lift trucks also have been used with the filling done directly along side the mechanical harvester in the field. Their use to date has been rather restricted partly because of the field filling problem. In order to fill the boxes directly on standard flat-rack trucks, it has been necessary to equip any of the standard commercial harvesters with specially built bulk loaders or to provide special low platform trailers low enough for the 4' deep boxes to be filled with the regular length bulk loaders. These trailers can be pulled for filling in the field with a tractor. This equipment would not be well adapted for long hauls from field to storage, but for short hauls, it does reduce the need for special transmissions or special gear ratios in trucks.

17. *Operating hazards* are generally no greater with potato harvesters than with several other items of farm equipment. *Safety features for the protection of machine or personnel,* shields over moving parts, slip clutches and other safety devices *should be kept in good condition.* Alert supervision and an alert crew contribute to the safety and productivity of the team.

18. *Good maintenance* includes most of the general rules for good farm machinery maintenance. Regular use of *lubricants kept clean* and *prompt attention to loose bolts* or *needed adjustments* are especially important. *Mechanized potato harvesting with its accompanying operations and the total crew involved make it a line production type of operation.* For this reason preventive maintenance is especially important in reducing labor costs due to unplanned interruptions for unanticipated but immediately necessary repair work. The good operator, when acquainted with his machine, can usually anticipate trouble and make corrections before it is serious enough to stop the production line.

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Machinery and Warehouse Disinfection In Potato Ring Rot Control

By D. S. MacLachlan

IT HAS BEEN demonstrated repeatedly that potato handling equipment such as mechanical planters, transporting vehicles, barrels, used potato bags, and storages are a potential source of ring rot infection. The knife used for cutting tubers into seed pieces, whether mechanical device or a paring knife, if often responsible for spreading or introducing ring rot in a potato crop. It has been shown that sets of as many as 40 to 50 tubers may be contaminated with ring rot following a cut through an infected tuber with a non-disinfected cutting knife. We have found as much as 6 percent ring rot infection in a crop grown from sets transported in contaminated potato bags. Planters, particularly the picker type, are as efficient as the cutting knife in spreading potato ring rot. Barrels, storages, wagons, and trucks used to transport seed potatoes, particularly cut sets, are a potential source of contamination. The seed potato grower should not, under any circumstances, allow persons cutting his seed to bring containers, cutting knives, or gloves onto his farm without first having these articles thoroughly disinfected. Similar precautions should be taken when the crop is being harvested. In Canada, the greatest spread of ring rot from farm to farm, other than by infected seed, is by interchange of cutting, planting, and harvesting equipment. If a grower has to borrow or lend potato handling equipment, he should see that it is thoroughly disinfected before he uses it on his own farm.

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Preparing for Disinfection

A large number of the disinfectants on the market today are highly active against the potato ring rot organism. However, these materials have one property in common which must not be overlooked. They lose their disinfecting properties rapidly in the presence of excessive amounts of dust, soil and organic materials. Because of this, the preparation of equipment for disinfection is of great importance. Machinery such as diggers, planters, wagons, trailers, etc., should be thoroughly cleaned, and where necessary washed with water, before the disinfectant is applied.

Disinfection

The quaternary ammonium compounds in general use today are, as a group, probably the most effective disinfectants against the ring rot bacteria. In addition to being excellent disinfectants, they are wetting agents, and thus penetrate more efficiently than other types of disinfectants. These compounds do not have disagreeable odors, and are relatively safe for humans to handle. Our experiments have indicated that quaternary ammonium compounds with phenol coefficients of from 13 to 20 can be used at a dilution of 1 pint to 25 gallons of water, while those with phenol coefficients of 20 to 25 may be used at a dilution of 1 pint to 30 gallons. No detergent or soap should be added to these materials. A few of the materials we have tested are as follows: Hyamine 2389; Purina Disinfectant; Roccal; Zephiran Chloride; Ocean 101; R-2-L; Teramine; San-O-Fec-25. These materials have proved effective against the ring rot organism on metal and wood surfaces and in jute bags. In dis-

infecting equipment such as crates, gloves, bags, etc., which must be dipped and soaked, it is important that the solution be changed when it becomes dirty. Because of the great variability in the amount of organic materials carried on these pieces of equipment it is impossible to state what number of crates, bags, or gloves may be disinfected in a stated quantity of disinfectant. If quaternary ammonium compounds are not available, 4 percent Lysol solution, or the coal tar disinfectants at a dilution of 1 to 40 may be used. These materials, however, have a very disagreeable odor, and if used in storages may cause off-flavors in the potato tuber. The results of our experiments at Ottawa have indicated that formalin and copper sulphate are not efficient bactericides in ring rot disinfection.

Although the quaternary ammonium compounds have proved effective in disinfecting machinery, they cannot be recommended for the cutting knife. To date, the only materials which have given consistent control of the ring rot organism on the cutting knife are mercuric chloride 1:1000 and 1:500, and Semesan Bel, one pound to 10 gallons. Both these materials are corrosive and poisonous and must be handled with care.

Disinfection by the Seed Potato Grower

The seed potato grower should use a different program than the table stock grower in disinfecting for bacterial ring rot. It is argued, and I believe rightly so, that when a seed grower has ring rot in his crop, the earlier it is detected, the better for all concerned. Trace amounts of bacterial ring rot may remain undetected in a seed source for many years. It is, therefore, to the advantage of the seed grower to use a disinfection program which will prevent the introduction of ring rot to his farm, and at the same time will simplify the detection of any ring rot which may be in his seed stock. This can be accomplished by thorough disinfection of all potato handling equipment brought onto the farm and by thorough spring and fall disinfection of of equipment already on the farm. Knife and planter disinfection should be performed only between different lots of seed, thus increasing the percentage of ring rot in a given lot of seed to a point where it can be readily detected.

Summary

1. A thorough disinfection program must be followed by the table stock and seed potato grower.
2. If possible, avoid borrowing or lending potato handling equipment.
3. Proper cleaning of potato handling equipment before disinfection is as important as the disinfection process.
4. Quaternary ammonium compounds are superior to other disinfectants on the market for the disinfection of potato handling equipment, storages, etc.
5. Semesan Bel and Mercuric Chloride are recommended for disinfection of the cutting knife.
6. The seed potato grower should modify his disinfection program so as to facilitate the detection of ring rot if it is present in his seed stock.

PUBLICATIONS OF INTEREST TO POTATO GROWERS

Agricultural Institute Review, 338 Somerset St., West Ottawa 4, Ont., Canada. Published bi-monthly by the Agricultural Institute of Canada. Editor, Hilda Gray. Subscription price 2.00 per year, foreign $2.50.

American Potato Journal, Potato Association of America, New Brunswick, N. J. Published monthly by the Potato Association of America. Editor, Dr. William H. Martin. Subscription price $4.00 per year. Foreign $5.00 per year. (Includes membership).

The Agronomy Journal, 2707 Monroe St., Madison 5, Wis. Published monthly by the American Society of Agronomy. Editor, L. G. Monthey. Subscription price $14.00 per year.

The American Vegetable Grower, 37841 Euclid Ave., Willoughby, Ohio. Published monthly. Editor, Richard T. Meister. Subscription price, $1.00 per year, 3 years $2.00, Canada and Foreign $1.50 per year.

The Badger Common 'Tator, Fidelty Bank Bldg., Antigo, Wis. Published monthly by the Wisconsin Potato Growers Association, Incorporated. Editor, Harold R. Simons. Price $1.00 per year or free to members.

Buckeye News, 3292 North High St., Columbus 2, Ohio. Editor, V. E. Keirns. Subscription price Free to grower members in Ohio.

California Kern County Potato News, P. O. Box 83, Bakersfield, Calif., official organ of Kern County Potato Growers Association. Published monthly. Editor, Francis P. Pusateri, Executive Manager. Subscription price free to members and associate members. Single copies free upon written request.

Colorado Potato Grower, 601 Cooper Bldg., Denver 2, Colo. Published monthly by the Colorado Potato Growers Exchange. Editor, L. E. Waters. Subscription price $1.00 per year.

Country Life in British Columbia, 207 West Hastings St., Vancouver 3, B. C. Published monthly. Official organ of B. C. Federation of Agriculture. Editor, J. R. Armstrong. Subscription price $1.50 per year, Canada, $2.00, U. S.

Fruit & Vegetable Review, Orange Savings Bank Bldg., Orange, Calif. Published monthly. Editor, A. J. Miller. Subscription price $3.00 per year.

The Guide Post, 5235 North Front St., Harrisburg, Pa. Published monthly by the Pennsylvania Cooperative Potato Growers, Inc. Editor James A. Hannah. Subscription price $5.00.

Hints to Potato Growers, New Jersey Agri. Experiment Station, New Brunswick, N. J. Published monthly by the New Jersey State Potato Association. Editor, John C. Campbell. Subscription price $3.00 per year.

Market Growers Journal, 11 South Forge St., Akron 4, Ohio. Published monthly. Managing Editor, Pat Waldron. Subscription price $2.00 one year, $3.00 2 years, $5.00, 5 years.

National Potato Council News, 542 Munsey Bldg., Washington 4, D. C. Published monthly by the National Potato Council, Inc.

The North Dakota Seed Journal, published and edited quarter-annually by the State Seed Department, State College Station, Fargo, North Dakota.

The Packer, 201 Delaware St., Kansas City 5, Mo. Published weekly. Editor R. V. Whiting. Subscription price $5.00 per year.

The Potato Chipper, 946 Hanna Bldg., Cleveland 15, Ohio. Published monthly by the National Potato Chip Institute. Editor, Harvey F. Noss. Subscription price $6.00 per year, $7.50 Foreign and Canada.

Potato News, Published by Empire State Potato Club, Inc., Georgetown, N. Y. Editor H. J. Evans. Subscription price—free to members only. Dues $3.00 per year.

Potato News From the Netherlands.

Pre Pack Age, 500 Fifth Ave., New York 36, N. Y. Published monthly, official organ of Produce Packaging Ass'n. Robert H. Weait, Editor and General Manager. Subscription price $3.00 per year.

The Produce News, 6 Harrison St., New York City 13. Published weekly. Editor, A. E. Haglund. Subscription price $5.00 per year.

Produce Reporter, 315 W. Wesley St., Wheaton, Ill., published semi-annually. Official organ of the Bluebook, fruit & produce credit book. Subscription price—on contract.

Seeder, P. O. Box 2601, Boise, Idaho. Published periodically by the Idaho Crop Improvement Ass'n. Editor, C. G. d'Easum. Subscription price—free.

"Spuditems," 815 First Avenue, Monte Vista, Colo. Published weekly by the San Luis Valley Potato Board of Control. Editor, V. Craig Johnson. Subscription price —free.

The Spudlight, 777-14th St., N. W., Washington 5, D. C. Published weekly by the Potato Division, United Fresh Fruit & Vegetable Association. Editor, Kris P. Bemis. Subscription price, to individuals and firms not eligible to be members of the United Fresh Fruit and Vegetable Association, $25.00 per year.

Tabb Potato Service, 9 South Kedzie Ave., Chicago, Ill. Editor, L. J. Crescio. Published weekly. Price $50.00 per year. (Also Tabb Onion Service, published weekly, price $50.00 per year).

The Valley Potato Grower, Box 301, East Grand Forks, Minn. Published semi-monthly by the Red River Valley Potato Growers Association. Editor, Lyle W. Currie. Subscription price—free.

Vee Gee Messenger, Preston, Maryland. Published bi-monthly. Editor, Max Chambers. Subscription price 20c per year, $1.00, six years.

Western Grower and Shipper, 606 South Hill St., Los Angeles 14, Calif. Published monthly as the official magazine of the Western Growers Association and the Kern County Potato Growers Association. Editor, Frank Howatt. Subscription price $2.50 per year.

What's New in Crops & Soils, 2702 Monroe Street, Madison 5, Wis. Published nine times a year by The American Society of Agronomy. Editor, L. G. Monthey. Subscription price $3.00 per year.

World Crops, Stratford House, 9 Eden St., London, N.W.I., England. Published monthly. J. Edward Thomas, Associated Editor. Subscription price $8.00 one year, $20.00, 3 years.

Production of Certified Seed Potatoes by Varieties — 1957

Compiled by ORRIN C. TURNQUIST

	Acres Entered	Acres Passed
ANTIGO		
Wisconsin	60.50	57.25
North Dakota	1.00	1.00
Total	61.50	58.25
BLISS TRIUMPH		
Minnesota	782.00	747.00
Nebraska	394.00	374.00
South Dakota	325.00	325.00
Montana	88.75	84.75
Main	—	61.00
Canada	60.00	41.00
Oregon	—	14.50
Wyoming	6.00	6.00
Minnesota	2.00	2.00
Colorado	2.00	2.00
North Dakota	1.00	1.00
California	1.00	—
Idaho	5.00	0.00
Total	1,666.75	1,658.25
BOONE		
North Carolina	92.30	89.10
Tennessee	4.00	4.00
Total	96.30	93.10
BURBANK		
Oregon	—	27.25
CANSO		
Canada	229.00	188.00
Nebraska	5.00	5.00
Wisconsin	.25	.25
Total	234.25	193.25
CANUS		
Wisconsin	.50	.50
CASCADE		
Oregon	—	0.8
CAYUGA		
Nebraska	6.00	1.00
CHEROKEE		
Minnesota	1,124.98	946.55
Maine	—	759.00
Michigan	223.00	206.00
Canada	119.00	85.00
New York	18.00	18.00
Nebraska	18.00	18.00
Vermont	20.00	12.00
South Dakota	8.00	8.00
Wisconsin	10.00	7.00
North Dakota	1.00	1.00
Total	1,541.98	2,060.55

	Acres Entered	Acres Passed
CHIPPEWA		
Maine	—	2,294.00
Wisconsin	604.00	448.25
New York	244.00	244.00
Michigan	83.00	77.00
Minnesota	44.50	44.50
Canada	231.00	34.00
New Jersey	34.00	34.00
Vermont	24.50	1.50
North Dakota	1.50	1.50
Wyoming	1.00	1.00
Total	1,267.50	3,179.75
COLUMBIA RUSSETT		
Canada	127.00	35.00
DAKOTA WHITE QUEEN		
North Dakota	7.00	7.00
DAZOC		
Nebraska	338.00	324.00
Minnesota	371.66	172.16
Colorado	59.20	59.20
Wyoming	50.00	50.00
North Dakota	45.00	25.00
Wisconsin	19.25	14.00
Oregon	—	3.00
Total	883.11	647.36
DELUS		
Wisconsin	3.75	3.75
Colorado	1.00	1.00
Total	4.75	4.75
EARLY GEM		
North Dakota	1,082.00	969.00
Wisconsin	294.00	250.00
Nebraska	159.00	155.00
Minnesota	102.40	85.40
Idaho	110.00	49.00
Wyoming	12.00	12.00
Montana	2.00	2.00
Colorado	0.50	0.50
Oregon	—	0.50
Total	1,761.90	1,523.40
EARLY OHIO		
Minnesota	303.50	268.50
North Dakota	241.00	241.00
South Dakota	44.00	44.00
Canada	69.00	9.00
Wisconsin	1.00	1.00
Total	658.50	563.50

	Acres Entered	Acres Passed
EARLY ROSE		
Washington	6.00	6.00
Maine	—	0.10
Total	6.00	6.10
EXCEL		
Nebraska	8.00	9.00
ESSEX		
New York	8.00	0.00
GOLDEN CHIP		
Oregon	—	4.00
GREEN MOUNTAIN		
Canada	4,718.00	2,421.00
Maine	—	726.00
New Hampshire	30.00	30.00
Vermont	37.00	21.00
Minnesota	14.50	14.50
New York	12.00	12.00
Wisconsin	5.25	5.25
Michigan	2.00	2.00
Total	4,818.75	3,231.75
HAIG		
Nebraska	11.00	11.00
HOUMA		
New Hampshire	1.00	1.00
HURON		
Canada	70.75	4.00
IRISH COBBLER		
Minnesota	10,081.40	9,068.00
Canada	4,507.00	4,035.00
Maine	—	3,156.00
North Dakota	1,784.00	1,667.50
South Dakota	139.00	139.00
Colorado	94.25	72.25
New York	43.00	43.00
Wisconsin	34.75	34.00
Wyoming	22.00	22.00
Maryland	20.00	20.00
Nebraska	14.00	14.00
Pennsylvania	7.00	7.00
Michigan	3.00	3.00
New Jersey	2.50	2.50
Total	16,751.90	18,283.25
KATAHDIN		
Maine	—	47,424.00
Canada	9,781.00	7,897.00
New York	1,163.00	1,113.00
Pennsylvania	579.50	492.50
Vermont	413.41	360.41
Wisconsin	237.25	180.75
Michigan	116.00	108.00
Colorado	94.35	78.10
New Jersey	65.50	65.50
Minnesota	42.25	42.25
Washington	14.00	14.00

	Acres Entered	Acres Passed
Idaho	3.00	3.00
Oregon	—	1.00
Total	12,509.26	57,779.51
KENNEBEC		
Canada	5,801.00	5,214.00
Maine	—	4,939.00
Minnesota	2,605.00	1,557.50
North Dakota	2,361.25	1,091.75
Oregon	—	280.75
Washington	211.00	211.00
Wisconsin	331.50	188.25
California	282.00	—
New York	103.00	102.00
South Dakota	74.00	74.00
Nebraska	32.00	29.00
Idaho	27.00	27.00
North Carolina	21.90	21.90
Utah	—	19.00
Wyoming	27.00	17.00
Vermont	10.00	10.00
Montana	10.00	10.00
Colorado	9.70	9.70
New Jersey	1.00	1.00
Virginia	1.00	1.00
New Hampshire	1.00	0.00
Total	11,909.35	13,803.85
KESWICK		
Maine	—	507.00
Canada	647.00	447.00
Wisconsin	79.75	79.75
Total	726.75	1,033.75
LA SALLE		
Wisconsin	4.50	4.50
LASODA		
Minnesota	81.25	67.25
South Dakota	119.00	59.00
Nebraska	41.00	22.00
New Mexico	20.00	20.00
Colorado	9.70	9.70
New Hampshire	4.00	4.00
Total	274.95	181.95
MANOTA		
Minnesota	27.00	27.00
North Dakota	3.00	3.00
Total	30.00	30.00
MERRIMACK		
Maine	—	21.00
New York	18.00	18.00
Wisconsin	14.25	14.25
Michigan	10.00	10.00
Minnesota	0.25	0.00
Total	42.50	63.25
NEW WHITE		
Minnesota	16.00	16.00

	Acres Entered	Acres Passed
NORLAND		
North Dakota	51.30	51.30
Minnesota	18.00	18.00
Total	69.30	69.30
ONAWAY		
Michigan	35.00	33.00
ONTARIO		
Wisconsin	355.50	326.50
Maine	—	253.00
New York	112.00	112.00
Total	467.50	691.50
OSAGE		
Minnesota	6.00	5.00
Wisconsin	0.50	0.50
Total	6.50	5.50
OSSEO		
Minnesota	4.60	4.60
Wisconsin	0.50	0.50
Total	5.10	5.10
PAWNEE		
Canada	3.00	3.00
Wisconsin	0.25	0.25
Total	3.25	3.25
PLYMOUTH		
Wisconsin	62.00	62.00
New York	12.00	12.00
Maine	—	11.00
Nebraska	1.00	1.00
Minnesota	0.50	0.50
Total	75.50	86.50
PONTIAC		
Canada	366.00	92.00
Idaho	46.00	46.00
New Mexico	20.00	20.00
Maine	—	14.00
Montana	5.00	5.00
Total	437.00	177.00
PROGRESS		
Nebraska	766.00	641.00
Colorado	4.00	4.00
Wyoming	40.00	3.00
South Dakota	1.00	1.00
Total	811.00	649.00
PUNGO		
Maine	—	149.00
Wisconsin	0.25	0.25
Total	0.25	149.25

	Acres Entered	Acres Passed
REDBAKE		
Nebraska	54.00	50.00
Minnesota	0.25	0.25
Total	54.25	50.25
RED BEAUTY		
Wisconsin	43.75	41.25
REDBURT		
Minnesota	76.25	66.25
REDGLO		
Nebraska	9.00	9.00
North Dakota	2.00	2.00
Colorado	0.50	0.50
Total	11.50	11.50
REDKOTE		
North Dakota	88.00	26.00
Minnesota	45.60	13.50
South Dakota	9.00	9.00
Montana	1.50	1.50
Colorado	0.50	0.50
Wisconsin	40.00	0.00
Total	184.60	50.50
RED LASODA		
Nebraska	1,714.00	1,571.00
South Dakota	685.00	625.00
North Dakota	681.50	570.50
Minnesota	343.60	327.10
Wisconsin	351.75	288.75
Colorado	41.26	41.76
Wyoming	48.00	17.00
Washington	2.00	0.00
Total	3,867.11	3,441.11
RED McCLURE		
Colorado	1,568.00	1,482.00
Wyoming	44.00	44.00
Total	1,612.00	1,526.00
RED PONTIAC		
North Dakota	15,683.95	12,020.20
Minnesota	10,842.40	8,966.40
Canada	1,264.00	869.00
Wisconsin	928.25	579.25
South Dakota	496.00	496.00
Colorado	595.50	492.50
Nebraska	532.00	452.00
Wyoming	132.00	—
California	110.00	—
Washington	101.00	86.00
Maine	—	38.00
New York	52.00	37.00
Utah	—	25.00
Oregon	—	18.50
Virginia	18.00	18.00
Pennsylvania	10.00	10.00
Michigan	14.00	7.00
Total	30,779.10	24,237.85

	Acres Entered	Acres Passed
RED SKIN		
New Jersey	1.25	1.25
RED SPORT TRIUMPH		
Wyoming	35.00	35.00
North Dakota	34.25	34.25
Nebraska	13.00	13.00
Total	82.25	82.25
RED TRIUMPH		
Minnesota	330.90	330.90
Wyoming	5.00	5.00
Wisconsin	2.00	2.00
Total	337.90	337.90
RED WARBA		
Minnesota	237.00	189.00
North Dakota	135.00	83.00
Wisconsin	43.50	23.25
Canada	33.00	20.00
Colorado	7.00	7.00
Total	455.50	322.25
RUKAT		
New York	16.00	16.00
RURAL NEW YORKER		
Colorado	100.30	66.80
Michigan	46.00	46.00
Maine	—	20.00
New York	16.00	16.00
Pennsylvania	8.00	0.00
Wisconsin	6.00	6.00
Total	176.30	154.80
RUSHMORE		
Wisconsin	24.25	23.25
South Dakota	21.00	6.00
North Dakota	4.70	4.70
Minnesota	3.10	2.00
Maine	—	0.80
Total	53.05	36.75
RUSSETT BURBANK (NETTED GEM)		
Idaho	15,531.00	13,670.00
Maine	—	4,646.00
Canada	4,047.00	3,821.00
Montana	2,584.25	2,578.25
Oregon	—	2,150.75
Colorado	1,839.00	1,676.00
Minnesota	1,900.95	1,669.45
Wisconsin	1,206.25	1,107.25
California	965.00	—
Washington	771.00	766.00
North Dakota	272.20	222.20
Utah	—	123.50
Wyoming	107.00	99.00
Michigan	32.00	32.00
South Dakota	30.00	30.00
New Mexico	20.00	20.00
New York	18.00	18.00

	Acres Entered	Acres Passed
Nebraska	11.00	11.00
Nevada	3.00	3.00
Total	29,337.65	32,643.40
RUSSET RURAL		
Michigan	436.00	426.00
Canada	413.00	386.00
Maine	—	238.00
New York	212.00	212.00
Colorado	130.70	83.00
Wisconsin	32.00	32.00
Nebraska	30.00	30.00
Total	1,253.70	1,407.00
RUSSET SEBAGO		
Wisconsin	435.50	410.50
Maine	—	24.00
Total	435.50	434.50
SACO		
Maine	—	141.00
New York	1.00	1.00
Wisconsin	0.25	0.25
Minnesota	0.25	0.00
Total	1.50	142.25
SARANAC		
Maine	—	0.30
SATAPA		
Wisconsin	0.75	0.75
SEBAGO		
Canada	21,713.00	20,350.00
Wisconsin	756.00	657.00
Michigan	571.00	547.00
New York	489.00	489.00
North Dakota	201.50	201.00
Minnesota	172.50	172.50
Maine	—	133.00
Pennsylvania	45.50	29.50
Delaware	23.00	23.00
Virginia	7.00	7.00
North Carolina	2.00	2.00
Total	23,980.50	22,611.00
SEQUOIA		
North Carolina	75.70	75.70
Michigan	36.00	36.00
Tennessee	16.00	16.00
Maine	—	12.00
Canada	8.00	8.00
Wisconsin	3.75	3.75
Total	139.45	151.45
SHERIDAN		
Nebraska	59.00	59.00
Delaware	19.00	19.00
Wisconsin	2.00	2.00
Minnesota	4.00	0.00
Total	84.00	80.00

	Acres Entered	*Acres Passed*
TAWA		
Wisconsin	24.75	24.75
Minnesota	8.25	7.50
Michigan	5.00	5.00
Nebraska	1.00	1.00
Oregon	—	0.10
Total	39.00	38.35
TETON		
Maine	—	345.00
Canada	8.00	8.00
Total	8.00	353.00
WARBA		
Canada	369.00	201.00
Maine	—	21.00
Minnesota	13.10	13.10
Total	382.10	235.10
WASECA		
Minnesota	239.00	229.00
Canada	75.00	10.00
North Dakota	10.00	10.00
Montana	0.75	0.75
Colorado	0.50	0.50
Wisconsin	0.25	0.25
Total	325.50	250.50

	Acres Entered	*Acres Passed*
WHITE CLOUD		
Nebraska	56.00	56.00
Wisconsin	4.25	4.25
South Dakota	2.00	2.00
Colorado	2.00	2.00
Total	64.25	64.25
WHITE ROSE		
California	3,731.00	—
Washington	903.00	838.00
Oregon	—	733.50
Utah	—	550.00
North Dakota	569.00	549.00
Idaho	210.00	179.00
Montana	150.00	150.00
Canada	145.00	134.00
Minnesota	34.00	34.00
Nebraska	33.00	33.00
Colorado	24.00	24.00
Wisconsin	0.75	0.75
New Mexico	20.00	0.00
Total	5,819.75	3,225.25
YAMPA		
Minnesota	5.60	5.60
Colorado	3.50	3.50
Total	9.10	9.10

Seed Cutting and Handling

By George W. French

Introduction

SEED CUTTING by hand is a seasonal operation which requires a large amount of labor for a period of short duration. Since most of the growers in a potato growing area begin operations at about the same time there may be an acute shortage of labor for hand cutting the seed tubers. The desire to reduce the dependence on extra labor is perhaps a factor that overshadows anticipated savings in direct cutting costs. Compared to land rent, cost of seed, and cost of harvesting, the actual cost of cutting the seed tubers is not a large item; however, delays in planting which may result from an inadequate supply of workers for hand cutting may result in indirect losses through less efficient use of field labor and field machinery.

In this discussion our consideration of seed handling includes all handling of whole tubers and cut pieces incidental to cutting, treating, transporting to the field, and filling plant hoppers.

Mechanical Seed Cutters

There are several makes of commercially manufactured seed cutters available. These machines can be classified as follows:

- I. Automatic Seed Cutters
  - A. "B" splitters
  - B. Multiple sizer-cutters
- II. Non-Automatic Seed Cutters
  - A. Selection of cut by operators
  - B. Selection of cut by machine

The automatic seed cutters are machines that feed the tubers into the cutting mechanism without any assistance from the operator. There are several makes of "B" splitters and all are simple in design. The multiple sizer-cutters are more complex as the machine cuts seed potatoes into 2, 3, or 4 pieces, depending on the size of the tuber.

The non-automatic machines are those in which the individual tubers are positioned in the mechanism by hand. The number of pieces into which a tuber is cut is determined by the operator's placement of the tuber in one type (A). In the other type (B) the individual tubers are positioned by hand but the machine automatically selects the number of pieces into which it will be cut. This selection is based on the length of the tuber. This type is not currently manufactured but several are still in use.

Quality of Mechanically Cut Seed

Cut seed samples from a number of mechanical cutters were collected and evaluated in respect to (1) uniformity of seed piece size and (2) incidence of seed pieces without eyes. It was found that, using these criteria, the mechanically-cut seed was generally approximately equal to hand-cut seed produced by people working under usual supervision.

Tests conducted with tubers selected by weight to be cut into seed pieces approximately $1\frac{1}{2}$ ounces in size indicate that an excessive proportion of seed pieces without eyes are produced when seed tubers are cut into more than 6 pieces. This is equally true of hand-cut seed and mechanically-cut seed where the hand cutters pay little attention to the positions of the eyes relative to making the cuts.

The shape of the seed piece produced by a mechanical seed cutter is a factor to consider in selecting a mechanical

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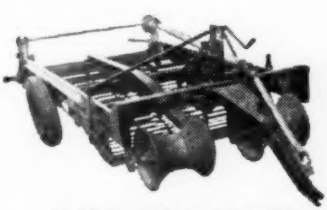

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seed cutter. A blocky seed piece is usually desired. An automatic cutter that is satisfactory for round varieties of potatoes will produce seed pieces that may be considered excessively long when used to cut long varieties of potatoes. Consequently the choice of a seed cutter will depend somewhat on the variety of potatoes to be cut.

Most of the seed cutters currently manufactured will cut tubers into a maximum of 4 seed pieces. The automatic cutters can not be used to make more than 4 seed pieces per tuber. Large tubers can be cut into 6 or 8 seed pieces with non-automatic cutters of the type where the selection of the number of seed pieces into which a tuber is cut is determined by the operator. The large tubers are split in halves with a hand knife and the two halves placed in the cutter to be cut into either 3 or 4 pieces each. There is one make of non-automatic seed cutter which will cut potatoes into 6 pieces without preliminary splitting by hand.

Cost of Mechanical Seed Cutting

The extent of the reduction in seed cutting costs that may be accomplished by the use of mechanical seed cutters as compared to hand cutting depends on (1) the amount of seed cut annually, (2) the ratio of the seed potatoes that are cut by the mechanical cutter to the oversize that must be cut by hand, (3) wage rates for hand cutting, and (4) the costs chargeable to the use of the cutter.

Commercial mechanical cutters vary in respect to initial cost, cutting capacity, and labor required for operation. If field run seed potatoes are used and the oversize tubers are cut by hand, the cost per bushel of using the cutter should apply only to the proportion of the tubers actually cut by the mechanical cutter. It is assumed that the labor cost of cutting the oversize tubers is at the same rate per bushel as would be the case if the entire seed lot is cut by hand. When a multiple sizer-cutter is used with unsized bin-run potatoes it is logical to include the oversize potatoes in estimating the annual repair costs on a seed quantity basis. This is based on the fact that the machine is running continuously and the rejection of oversize tubers does not decrease wear on the machine. In fact, an excess of oversize tubers in the seed lot may increase machine wear as the rate that the oversize tubers can be cut by hand may extend the duration of machine use. Table 1 and Figure 1 show the relationship of oversize percentage and annual use to machine costs. The machine costs include fixed annual charges for depreciation and interest regardless of use. The estimated annual cost of repairs is based on maximum of \$5.00 per \$100 of machine cost when the machine is used on 4800 cwt. annually. This amounts to .10416 cent per cwt. Since the repair cost can be expected to be proportional to the use, this figure is multiplied by the total number of hundred weight run through the machine to compute the annual repair cost when the total amount of seed cut is more or less than 4800 cwt.

Machine cost, as discussed above can be computed on the basis of cost per 100 cwt. of seed actually cut mechanically by the three following equations:

(1) Depreciation (\$ per 100 cwt.) $= \dfrac{1000\,P}{Q\,(100 - \%\ \text{O.S.})}$ *

(2) Interest (\$ per 100 cwt.) $= \dfrac{300\,P}{Q\,(100 - \%\ \text{O.S.})}$

(3) Repairs (\$ per 100 cwt.) $= \dfrac{.10416\,P}{100 - \%\ \text{O.S.}}$

(4) Total Cost (\$ per 100 cwt.) $= \dfrac{P}{100 - \%\ \text{O.S.}} \left(\dfrac{1300}{Q} + .10416 \right)$

*P = Price (\$) of machine.
Q = Total amount (cwt.) of seed cut annually.
% O.S. = Percentage (by weight) of oversize tubers.

Figure 1 is a line chart based on equation (4) which illustrates the relationship of mechanical seed cutter costs to the quantity of seed cut annually and the percentage of oversize tubers in the seed lots. Table 1 shows the same relationship on the "total" lines for the same oversize percentages

TABLE 1.

Relationship of Machine Cost Per 100 Cwt. Per $100 of Mechanical Cutter Price to Annual Use and Tuber Size Distribution.

% O. S.	Depreciation* (D) Interest (I) Repairs (R)	QUANTITY OF SEED POTATOES USED ANNUALLY									
		500	1000	1500	2000	2500	3000	3500	4000	4500	5000
	D+I	8.680	4.335	2.890	2.167	1.734	1.445	1.239	1.083	.963	.868
70	R	.347	.347	.347	.347	.347	.347	.347	.347	.347	.347
	Total	9.027	4.682	3.237	2.514	2.081	1.792	1.586	1.430	1.310	1.215
	D+I	6.500	3.250	2.165	1.625	1.300	1.083	.930	.814	.723	.650
60	R	.260	.260	.260	.260	.260	.260	.260	.260	.260	.260
	Total	6.760	3.510	2.425	1.885	1.560	1.343	1.190	1.074	.983	.910
	D+I	5.210	2.600	1.734	1.300	1.040	.868	.744	.651	.579	.521
50	R	.208	.208	.208	.208	.208	.208	.208	.208	.208	.208
	Total	5.418	2.808	1.942	1.508	1.248	1.076	.952	.859	.787	.729
	D+I	4.340	2.172	1.446	1.086	.868	.724	.620	.542	.482	.434
40	R	.174	.174	.174	.174	.174	.174	.174	.174	.174	.174
	Total	4.514	2.346	1.620	1.260	1.042	.898	.794	.716	.656	.608
	D+I	3.250	1.625	1.081	.813	.650	.542	.464	.406	.361	.325
20	R	.130	.130	.130	.130	.130	.130	.130	.130	.130	.130
	Total	3.380	1.755	1.211	.943	.780	.672	.594	.536	.491	.455
	D+I	2.600	1.300	.867	.650	.520	.434	.372	.325	.289	.260
0	R	.104	.104	.104	.104	.104	.104	.104	.104	.104	.104
	Total	2.704	1.404	.971	.754	.624	.538	.476	.429	.393	.364

* The depreciation (D) is calculated at 10% per year. Interest (I) is computed at 6% on one-half of the cost. The total repair cost is calculated at $0.104 per 100 cwt. fed to the mechanical cutter. The cost per 100 cwt. is based on the tubers actually cut by the mechanical cutter.

and selected values for total quantity of seed used annually. In addition, Table 1, shows the distribution of total cost between the fixed changes (depreciation and interest) and repairs.

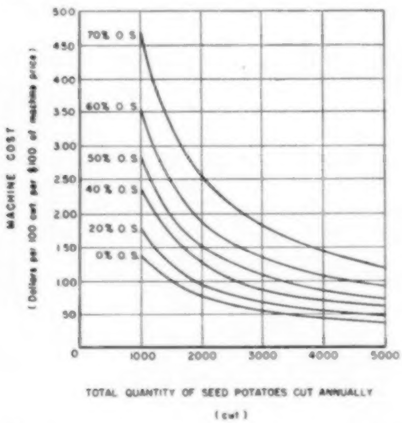

FIGURE 1. Machine cost for using mechanical seed potato cutter as related to the quantity of seed potatoes cut annually and the percentage of oversize tubers in the seed lot. (The oversize tubers are those of a size too large to be cut by the mechanical cutter, without any preliminary hand cutting, into the correct number of pieces to produce seed pieces of approximately the desired average size.) The unit-machine cost is based on the actual amount of seed cut by the mechanical cutter. For a given total quantity of seed cut the amount mechanically cut is inversely proportional to the oversize percentage.

Pre-Sized Seed Potatoes In Relation to Stand and Quantity of Seed Required

Seed cutting tests with Red Pontiac potatoes indicate that approximately 25% of the seed pieces will be devoid of eyes when seed tubers are cut into 8 pieces. Tubers cut into 6 pieces will produce seed pieces of which about 5% will be devoid of eyes. When tubers are cut into not more than four pieces, practically all of the pieces will have one or more good eyes. In bin-run seed potatoes, which include a high proportion of large tubers that are cut into 8 pieces, the seed thus produced will have an excessive number of pieces without eyes. Table 2 illustrates this relationship.

The average seed piece size desired is to some extent a matter of choice by the grower. It appears, however, that an average seed piece weight of $1\frac{1}{2}$ ounces is the size most widely preferred by growers in the Red River Valley. If seed tubers weighing from 2 ounces tc 13 ounces are cut as shown in Table 3 the average seed piece weight will be approximately $1\frac{1}{2}$ ounces. The relationship of seed piece weight to the amount of seed required per acre is illustrated graphically in Figure 2.

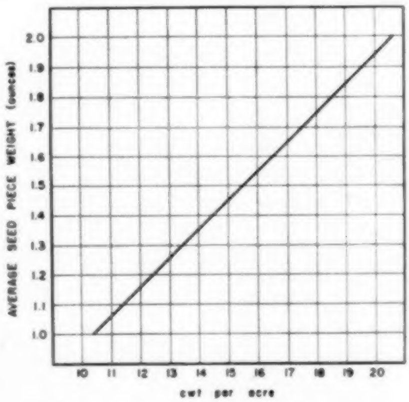

FIGURE 2: Seed piece weight as related to the amount of seed required per acre with 38-inch row spacing and 10-inch seed piece spacing in the row.

$$\text{cwt per acre} = \frac{3920\ W}{S \times D}$$

WHERE:
W = Average seep piece weight (ounces)
S = Row spacing (inches)
D = Seed piece spacing in the row (inches)

This table is based on a study made with Red Pontiac potatoes in which it was found that tubers cut into 6 pieces resulted in the production of seed pieces of which 5% were devoid

TABLE 2.

Seed Pieces Per Tuber as Related to Seed Pieces Without Eyes.

% By Wt. Cut Into 8 Seed Pieces											
100	5.0										
90	4.5	7.0									
80	4.0	6.5	9.0								
70	3.5	6.0	8.5	11.0							
60	3.0	5.5	8.0	10.5	13.0						
50	2.5	5.0	7.5	10.0	12.5	15.0					
40	2.0	4.5	7.0	9.5	12.0	14.5	17.0				
30	1.5	4.0	6.5	9.0	11.5	14.0	16.5	19.0			
20	1.0	3.5	6.0	8.5	11.0	13.5	16.0	18.5	21.0		
10	0.5	3.0	5.5	8.0	10.5	13.0	15.5	18.0	20.5	23.0	
0	0.0	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0
	0	10	20	30	40	50	60	70	80	90	100

% By Wt. Cut Into 6 Seed Pieces

TABLE 3.

Tuber size divisions for producing seed pieces averaging 1¼, 1½, or 1¾ ounces.

Seed Pieces Per Tuber

	2	3	4	6	8
Tuber Size Range (Ozs.) for 1¼ Oz. Average Seed Piece					
Min.	2	3	4½	5½	9½
Max.	3	4½	5½	9½	11½
Tuber Size Range (Ozs.) for 1½ Oz. Average Seed Piece					
Min.	2	4	5	7	11
Max.	4	5	7	11	13
Tuber Size Range (Ozs.) for 1¾ Oz. Average Seed Piece					
Min.	2½	4	6½	7½	13½
Max.	4	6½	7½	13½	14½

of eyes. Cutting tubers into 8 pieces produced seed pieces of which 25% were without eyes. Seed pieces from tubers cut into 2, 3, or 4 pieces did not produce any blank pieces.

The following example illustrates the use of this table. It is desired to produce $1\frac{1}{2}$ ounce seed pieces from seed potatoes with the following size distribution (by weight):

%	Tuber Size Range (Oz.)	Seed Pieces Per Tuber
50	2 to 7	2, 3, or 4
30	7 to 11	6
20	11 to 13	8

From the table it is found that 6.5% of the total seed pieces would be devoid of eyes.

Handling of Cut Potato Seed

The seed cutting, whether by hand or with a mechanical cutter, is invariably (as far as is known) done at the storage. The cut seed may be transported to the field in bags on a flat-bed truck or in bulk in a self-unloading truck box which is used in receiving potatoes from mechanical harvesters. This discussion is intended to emphasize methods rather than details of equipment and operation.

The merits of bulk handling versus bag handling of cut seed should be considered in conjunction with a number of other factors involved in the seed handling operations. These factors included:

1. Amount of seed planted annually.
2. Equipment available (including power source for operating handling equipment in the field) for quickly refilling planter boxes.
3. Chemical treatment of seed—in the warehouse or in the field.
4. Type of labor available (bulk handling can eliminate arduous labor of handling bags of seed in the field.)

The handling of seed in bulk self-unloading boxes requires some power source for driving the conveyor in the self-unloading box and the transfer conveyor used to place the cut seed in the planter hopper, or in a treating tank if the seed is treated in the field.

FIGURE 3. Gasoline engine driven transfer conveyor. This unit is mounted on two pneumatic tired wheels. It is attached to the trailer hitch of the truck and can be quickly detached when the self-unloading box is emptied. The unloading conveyor in hopper box on the truck is driven by the truck engine. This system of filling the planter hoppers has the merit of mobility as the unit can be readily moved for distributing the cut seed as the hoppers are filled. About 5 minutes were required to fill the hoppers of a two-row planter. The capacity of the unloading conveyor in the truck hopper box was the limiting element in this case. The cut seed was planted without any chemical treatment.

The self-unloading boxes, when used in harvesting operations, are unloaded at the warehouse; where suitable electric service is generally available for driving the unloading conveyor. In the field a different power source must usually be provided. Some power sources used for operating seed handling equipment in the field are listed below:

1. Small portable gasoline engine.
2. Engine of seed hauling truck through p.t.o. on transmission.
3. 110-volt or 220-volt generator mounted on the tractor, used for pulling the planter.
4. 6-volt or 12-volt battery and an auto or truck engine starting motor.

All of these power sources have been used successfully for operating bulk seed handling equipment in the field. It is, of course, necessary to design the drive system to suit the power unit and provide the correct speed for the conveyors to be driven. A direct current starting motor can provide ample power for short periods of intermittent operation; but will overheat if used continuously until a full truck box is unloaded.

If the seed is transferred directly (no field seed treatment) from the bulk box to the planter hopper the conveyors should have a high capacity so a minimum of time will be required for refilling the seed hoppers on the planter. Another requirement is portability and ease of regulating the position of the transfer conveyor relative to the planter hopper. From the standpoint of this latter consideration it is preferable to have the transfer conveyor designed to deliver the seed to the side rather than straight back from the truck. With this arrangement the truck can be driven forward or backward as necessary to distribute the seed evenly in the planter seed hopper.

Seed treating. Chemical seed treatment may be applied at the warehouse or in the field. If the seed is treated at the warehouse using a continuous treating tank the treating operation requires no additional labor; whereas field treating requires an additional man in the field to keep one two-row planter supplied with seed. It may be possible, with an efficient field seed handling system, for one man to treat seed for two planters; but in the operations studied where two planters were used two men were required to handle the seed treating.

Field treatment of cut potato seed requires more labor than treating the seed at the warehouse. However, there are two advantages to performing this operation in the field which some operators may feel are worth more than the additional labor required.

One advantage is that when the seed is treated in the field only enough seed for one planter refill is treated at one time. If planting is interrupted by rain only a few bushels of treated seed will be on hand; whereas a truck load of treated seed may be left unplanted when the seed is treated at the warehouse.

Another advantage of field treating in respect to handling is the rapidity with which the planter hoppers can be refilled. The cut seed is placed in a crate which is then immersed in a tank partially filled with treating solution. The crate is equipped with a door in the bottom so that the seed can be quickly dropped into the planter hopper.

Two systems, with various modifications, are used in handling the crates after they are filled with seed. In one system the crates are lowered, raised, and moved into position for filling the planter hoppers by semi-stationary hoisting equipment which may be power driven or hand operated. The treating and handling equipment is located at one end of the field (or in the middle if the rows are much longer than ½ mile) and the planter is taken to the treating and handling station for

refilling. In the other system the treating tank is semi-stationary and the crate of treated seed is carried to the planter with a tractor equipped with a front-end loader or other suitable hoisting equipment. From the standpoint of time required for refilling the planter with seed and personnel requirements there are no marked differences in the merits of the two systems. Perhaps the most important factor in the selection of one system over the other would be the kind of equipment most readily available. Figures 3 to 7 are photographs illustrating some different seed handling methods.

When the chemical used for treating the seed either in the field or at the warehouse is corrosive, this factor should be considered in the design of the seed handling equipment and the selection of materials for construction. It is also necessary to provide protection for the workers who come into contact with the treating solution. It is not within the scope of this study to evaluate the merits of the different chemicals that are used for potato seed treating, but the characteristics of the substance to be used should be considered in selecting equipment for this purpose. Studies on the effectiveness of different chemicals used for seed treating have been reported elsewhere.[1]

(1) Hoyman, W. G. 1957, Potato Seed Treatments in 1956. N. Dakota Agr. Exp. Sta. *Bimonthly Bulletin*. Vol. XIX, No. 4.

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The views and recommendations found in the articles in this issue are those of the authors and not necessarily those of the officers or directors of the Potato Association of America.

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Oregon Potato Commission, 632 Sixth St., Redmond, Ore. Secretary and Administrator, Ben Davidson, 249 Sixth St., Redmond.

Central Oregon Potato Growers Association, 632 Sixth St., Redmond, Oregon. Secretary, Robert Beasley, Route 1, Bend, Ore.

Pennsylvania Cooperative Potato Growers, Inc., 5235 North Front St., Harrisburg, Pa. Publishers of "The Guide Post." General Manager, Owen L. Barkley, 5235 N. Front, Harrisburg; Secretary and Educational Director, James A. Hannah, 5235 N. Front, Harrisburg.

Pennsylvania Vegetable Growers Association, P.O. Box 1423, Kingston, Pa. (Publishers of Penna. Vegetable Growers News). Secretary-Treasurer, James A. Garrahan, Box 1423, Kingston.

Pennsylvania Potato Industries, Inc., Potato City, Coudersport, Penna. (Publishers of Potato Receipts). Secretary, James A. Hannah, 5235 North Front St., Harrisburg, Pa.

Rhode Island Potato Growers Association, 83 Park St., Providence, R. I. Secretary, Roland L. Swallow, Providence.

South Dakota Potato Growers Association, Box 671, Watertown, S. Dakota. Publishers of "Rules and Regulations for Certification". Secretary, John Noonan, Watertown.

Associated Growers of Hereford, Box 302, Hereford, Texas.

Puite County Potato Growers Association, Circleville, Puite County, Utah.

Utah Crop Improvement Association, Utah Agricultural Experiment Station, Logan, Utah. Secretary-Treasurer, Golden L. Stoker, Logan.

Vermont Certified Seed and Potato Growers Association, Vermont Dept. of Agriculture, Montpelier, Vt. Secretary-Treasurer, John W. Scott, Montpelier.

Association of Virginia Potato and Vegetable Growers, Inc., P.O. Box 125, Belle Haven, Va. Secretary, George R. Mapp, Jr., Belle Haven.

Pacific Northwest Certified Seed Potato Co-operative Association, Lynden, Washington. Secretary-Treasurer, R. W. McGowan, Route 1, Ferndale.

Washington Certified Potato Growers Association, c/o Oliver Bolstad, RFD 3, Lynden, Wash.

Washington Potato and Onion Shippers Association, Inc., 100 N. 7th Ave., P.O. Box 998, Yakima, Wash. Manager, Fred L. Ramsey, Yakima.

West Virginia Potato Growers Association, Oglebay Hall, Morgantown, West Va. Secretary, Claude R. Kemper, Morgantown.

Wisconsin Potato Growers Association, Inc., Fidelity Bank Bldg., Antigo, Wis. Publishers of "The Badger Common Tater." Executive Secretary, Harold R. Simons, Antigo.

Wyoming Crop Improvement Association, College of Agriculture, University of Wyoming, Laramie, Wyoming. Secretary, Charles Allen, Laramie.

Better Quality Potatoes Through Timely Vine-Killing

By John A. Schoenemann

THERE ARE several reasons why up-to-date potato growers kill vines well ahead of digging time and this year more than ever before the emphasis should be on quality. Anything we can do to raise the market quality of our potatoes will definitely be all to the good. The practice of *early* vine killing either by mechanical or chemical means is a common one. It results in a more uniform crop of higher grade. It toughens the skin and makes for an easier job of digging and handling. If timed properly it can be done without any appreciable reduction in cooking quality (dry matter content).

It is often felt that vine killing one to two weeks prior to harvest will reduce potato yields. The important thing, however, is that while *total yield per acre* may be reduced somewhat the *yield* of uniform sized tubers $1\frac{7}{8}$ to $2\frac{1}{2}$ inches in diameter, with tight skins, and free of bruises can be significantly increased through proper, timely vine killing. These are the kind of potatoes the market is interested in and can mean better returns for the grower in any season.

Besides better maturity and a higher percentage of marketable potatoes, timely vine killing has several other advantages. It prevents oversize tubers, allows for easier digging and picking, can reduce losses in storage and avoids spread of virus diseases, which may occur late in the growing season. This latter point is of particular importance for growers who produce certified seed. With today's modern combine type potato harvesters the importance of fully matured tubers, which separate easily from the vines and with completely dry vines which do not tend to clog the elevators, is even more essential.

How can the vine killing job best be done? Either mechanical vine beating or chemical spraying can be used. However, a combination of chemical and mechanical killing is offering some real advantages over a chemical or mechanical means alone. For fields of early varieties with a moderate amount of top growth spray with a chemical, then rotobeat about three to five days later. Harvest seven to ten days after the initial spraying was done. For fields of midseason or late varities with heavy green tops rotobeat and then spray with a chemical vine killer a day or two later. Harvest when tubers are fully mature which will usually take a full two weeks or more after the initial rotobeating. For fields with just a light amount of top growth spraying with a chemical only, is usually sufficient, while with fields of early or midsummer varieties where a "natural" maturity has already set in, rotobeating only is satisfactory for good maturity and easy harvest. Incidentally, be sure rotobeaters are set high enough to avoid injury to shallow set tubers.

What about chemical spray vine killing recommendations. How much of what material should be used? Our Wisconsin Agricultural Experiment Station and Extension Service recommendations are as follows: Use one to two pounds of dinitro (one to two quarts of a material such as Dow General or Sinox General) plus 5 gallons of fuel oil mixed with water, *or* 10 to 15 pounds of sodium arsenite (one to one and one-half gallons of a sodium arsenite preparation containing 10 to 14 pounds of sodium arsenite equiva-

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lent per gallon). Either dinitro or sodium arsenite should be applied in from 100 to 125 gallons of water per acre. A spreader-sticker added to the spray solution may be helpful with some sodium arsenite preparations.

There has been some rumor recently in some Wisconsin potato growing areas to the effect that the use of sodium arsenite preparations for potato vine killing will cause the tubers harvested from vines so treated to turn black after cooking. It should be clearly understood that to the best of our knowledge there is no factual basis for this to be true. The reasons for this are many and quite substantial. Sodium arsenite used for vine killing is not new. While comparatively new in Wisconsin it has been used in eastern potato states for the last five years or more. No reports have come from these areas stating or even rumoring that sodium arsenite vine killing might cause blackening. Also, extensive and varied research has been done on the whole blackening problem in Wisconsin and elsewhere since the 1930s and even earlier. In none of this research has it been indicated that the presence of arsenic on vines or in soil could cause blackening. Also, the approval of sodium arsenite as a vine killer by the Federal authorities was only given on the basis that it could not be absorbed by the potato plant or translocated to the tubers. In addition several plantings of five different varieties of potatoes have been harvested at the Hancock Experiment Station this season. All of these test plots had been killed prior to harvest with sodium arsenite. Several lots of each harvest have been cooked with the result of no evidence of darkening after cooking. This matter will be investigated further in the interests of providing Wisconsin growers with the best information possible.

A temperature of 65 to 70 degrees or above is needed for a good job of killing when using dinitro materials.

Current Status of Mechanical Potato Harvesting

By A. H. Glaves and Geo. W. French

WHAT is the present status of potato harvester developments? How mature are the designs of production models being offered to growers? Is this a good time to convert potato harvesting operations to a more completely mechanized system? Or, is now a good time to trade in an old harvester on a newer model? Or, have features and principles of operation in the various designs become stabilized? Are recently developed features firmly established or likely to be displaced by different features? Are there new features now in prospect which are likely to replace features or specifications of machines currently on the market? Are present designs close to the ultimate answer or in what respects are we most likely to see further changes?

These and similar questions seem not to have any firm, permanent answer. Many of the answers do not apply with equal weight to individual cases or to different areas. This will probably remain true for a long time. A review of developments during the last decade, a discussion of trends, basic functions, and various means of their accomplishment may serve as a guide to interested growers in generating their own answers to some of these questions, or may be helpful in choosing a machine well adapted to an individual situation.

A general knowledge of features, specifications, principles of operation, adaptations, and changes or trends in recent years, especially combined with some experience in the use of a mechanical harvester, can give a perspective for evaluating progress to date and probable further improvements.

It is the purpose of this article to present a condensed review of most of the more significant changes which have contributed to progress toward more nearly complete, effective and economical mechanization of the potato harvest. This writing is based largely on field observations of many experimental and commercial production models of potato harvesters without and with experimental or special modifications. These observations were by a staff of two to three men working principally in the Red River Valley of Minnesota and North Dakota from 1948 through 1956 and supplemented by field trips, contacts, and consultations, with engineers, builders and users of potato harvesters in twelve other states including Maine, Florida, Alabama, Arizona, California, and Idaho, for a total of 20 man-seasons in distant areas and 25 man-seasons in the Red River Valley area. Hundreds of patents on potato harvesting equipment of U.S. and foreign origin have been screened or studied. Many of these have been discussed with inventors, specialists, and users who have consulted at the Red River Valley Potato Research Center. Some were promoting ideas; others were seeking information for possible application in other important potato producing areas of the U.S. and many foreign countries.

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Although our day after day field experiences have been most concentrated in the Red River Valley, and will be most directly applicable here, other wide-spread contacts and sources of information have developed a broad background for evaluating recent progress towards more universal adaptations, more versatile designs and more efficient machines.

Even with the great progress already gained and a broad background of first hand field observations, it is difficult to estimate how far toward the ultimate equipment and methods or how fast these goals may be reached. In view of continuing relatively rapid evolution any possible prediction would surely be subject to annual revision.

Some Early Developments

A great many potato growers and others have made many attempts throughout the last century to increase the mechanization of harvesting of potatoes and reduce its drudgery. Most of these efforts yielded no major developments, other than improvements in pototo diggers, that came to be widely used until farm tractors had largely displaced horses and power-take-off accessories came into general use. At one time a small percentage of horse drawn diggers were equipped with gasoline engines for driving the aprons. When tractors replaced horses for pulling diggers pto drives replaced engines on diggers.

The search for information on early developments of harvesters has revealed that one machine built and used in 1927 was pulled by horses, *had its own 4-cylinder water cooled engine, and was designed to deliver potatoes in bulk* into a wagon pulled alongside the harvester*. The wagon box was made with individually removable planks for unloading through hatches into pits or into a conveyor below. This rather simple and some what crude equipment for *mechanical harvesting combined with bulk handling* from field to storage is the earliest we have discovered to date.

The advent of rubber tires on the tractors, the more general use of motor trucks on farms, the continued improvement and refinement of other farm equipment, the diminishing supply of farm labor and other economic factors stimulated and contributed to more active developments for mechanizing the potato harvest. Progress was relatively slow until several of these factors operating simultaneously exerted pressure and opened opportunities simultaneously. Acceleration of harvester development activities greatly increased during the period from 1945 to 1950 in several areas. More rapid progress and more significant developments were made, and mechanical harvesting gained more widespread acceptance during the last ten years. This period approximately coincides with the initiation, in the Red River Valley, of potato harvesting studies and development in 1948, by the U.S. Dept. of Agriculture under the Research and Marketing Act of 1946. Although the work was centered in the Red River Valley it was aimed toward the generation of basic information and the promotion of machine developments with wide utility and maximum standardization for country-wide use.

The policy followed and methods used have emphasized the analysis of functions and explorations of variations of functional solutions which might be incorporated in commercially manufactured machines.

Combined with this has been field observations on where and how potato damage was produced, how it could be reduced and comparisons of methods of management which might aid growers in more effective use of their machines. Details for improvement of components such as sprock-

*This was done by A. H. Small near Kalispell, Mont.

ets and chain links have been discovered and pointed out in consultations with both users and manufacturers of machines. Opportunities for making specific improvements in individual models were observed. This information was used in carrying out a policy of close cooperation and consultation with manufacturers in the improvement of their various models.

The Functions and Duties of a Potato Harvester

A potato harvester must perform several functions under a wide variety of field conditions, in widely different types of soils, and with adequately gentle handling of potatoes of very different varieties, shapes and sizes. Objectives aimed at maximum mechanization of potato harvesting constantly lead these endeavors toward the combination of all necessary functions into one complex machine. These functions are: (1) excavation; (2) elevation, separation of loose soil; (3) separation of clods or stones larger than the smallest tubers to be recovered; (4) vine elimination including tuber stripping if immature enough to be clinging; (5) provision for at least some sight inspection or hand sorting; and (6) transfer into bulk transport box, or smaller handling containers such as bags, barrels, crates, or pallet boxes for fork lift handling. It must operate with high capacity, good economy, and dependability through season after season with a minimum of risk from unfavorable weather. Capacities now expected in areas such as the Red River Valley where mechanized methods have become dominant are from one to two acres per hour under average to favorable conditions. A two-row harvester traveling at 2 mph. (where the row spacing is 38") will cover ground at a rate of approximately 1½ acres per hour. If it has two 26" aprons running at an average depth of 4" it would lift about 254 cu. ft. or about 8 to 10 tons of soil per minute. At an average depth of only 3" it might still lift more than 7 tons of soil per minute. with a 300 bu./A yield the machine would be expected to lift 7 to 10 tons of soil per minute and separate about 450 pounds of potatoes from it. As one English publication has expressed the requirement (with a closer row spacing and the machine lifting the entire ridge) a machine in harvesting one acre of potatoes may lift 390 tons of extraneous material besides the 10 tons of potatoes to be separated, cleaned and saved. This might be much less difficult to accomplish mechanically if it were not for the very wide range in soil conditions and a great assortment in the size and shape of tubers to be recovered. Then in stony areas there are the added problems of the separation of various sizes and shapes of stones, and the necessary structural strength and protective features required to give the machine reasonable dependability and longevity. The design should also include adequate shielding and other protective devices for maximum safety to operating personnel.

General Harvester Design and its Evolution

Early attempts to produce a harvester generally consisted of a conveyor-bagger trailer for attachment to a digger and with provision for carrying workers for hand sorting and bagging (or in some cases filling crates). One step further in advance was the incorporation of all functional assemblies into a single frame instead of having two articulated units. In the earlier and more simple forms the movement of material was generally from front to rear and with delivery of potatoes in containers off the rear of the machine onto the ground. (In a few instances bagged potatoes were delivered off the rear of the harvester onto a trailing vehicle.) Between 200 and 300 machines,

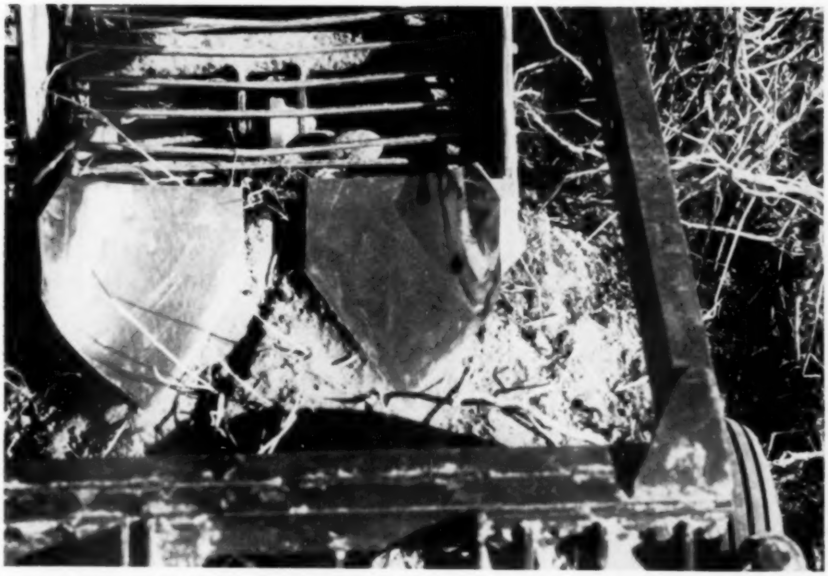


FIGURE 1. An example of an "open center" blade design. (Dahlman)

FIGURE 2. This is one of the successful rotary rod bladeless designs. Research and development of blade substitutes are continuing.

mostly of this type, had been built and used in Idaho by 1945*. A slightly later development in Idaho was a multiple-roller cleaning bed (with 13 to 18 rubber rollers about 3" to 3¾" diameter, x 26" long and spaced 1¼" apart). These specially constructed "separating rolls" were in fixed positions, all turning the same direction, and the assembly positioned to deliver the potatoes toward the rear, or in case of two-row machines and some one-row machines for bulk handling, toward one side. These rearward flow machines were followed by L-flow and by reverse flow machines with potato delivery from the front of the machine. (See flow diagrams 1, 2, 3, and 4.) This reduced overall machine length, improved maneuverability and provided for greater distance of conveyor travel to accomplish a greater degree of separation. The earlier ones of these were also generally one-row machines, or single apron indirect machines for picking up two-row windrows, pulled by a tractor and power-take-off driven. A hinged elevator was substituted for bagging accessories on the right front corner for delivery of potatoes in bulk into a truck traveling alongside the machine.

Machines of this general description demonstrated their possibilities in Colorado and in North Dakota in 1947 and 1948. These successes plus the advent of bulk handling in Idaho about the same time further established their merits, and demonstrated in these areas the economy and practicality of mechanical harvesting when combined with bulk handling.

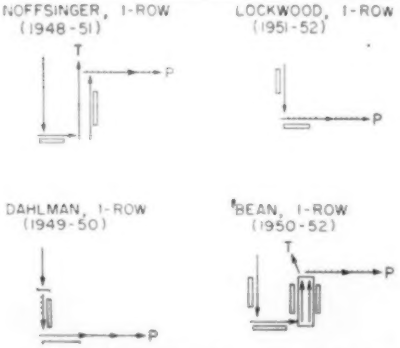
A few bagger type harvesters were used in the Red River Valley from 1947 to 1950 but most of these could be classed as experimental. (None of these are represented in the flow diagrams.) Popular demand developed for harvesters with bulk loaders and hopper-shaped truck boxes with unloading conveyors displaced many dump truck boxes which were first used by some growers. Improvements in hauling equipment, unloading and bin filling equipment accompanied the increased mechanization in the field. During these years, pto drives were generally abandoned and most harvesters were equipped with their own motors. This, by providing apron speed control entirely independent from travel speeds, improved their adaptability to varying field conditions and aided the operator in gaining maximum operating capacity consistent with operating conditions.

In 1950 and 1951 it was demonstrated practical and sometimes advantageous to modify one-row or "single apron" harvesters for indirect operation to meet adverse field conditions and to obtain two-row capacity. In order to do this, two-row diggers were equipped with any one of three types of windrowing equipment: (1) a plain rectangular padded funnel on the rear of the digger; (2) a single-apron cross-conveyor; or (3) twin-apron center-delivery conveyors. The first models of all three types were not too well designed. They had both functional deficiencies and mechanical weaknesses. Some had bare rod aprons of stock only 5/16" in diameter which resulted in tuber damage as they dropped too great a distance from the digger apron to the cross conveyor apron. Some cross conveyors were operated at too high speeds. (Seventy to 80% of digger apron speed has been found generally adequate.) Some were mispositioned in mounting the cross conveyors on diggers not well suited to this purpose. Frequently the damage done by inadequate or poorly operated digger-windrowers was much greater than that done by the second stage of indirect harvesting: pickup, separation, and loading into bulk trucks. With functional improve-

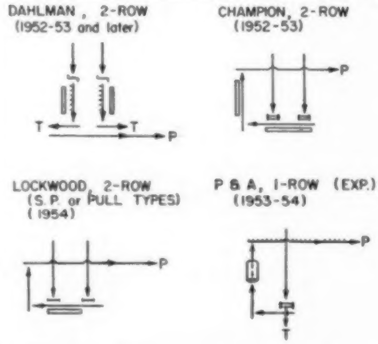
*Reported in Idaho Agricultural Experiment Station Bulletin No. 283.

Flow Diagrams

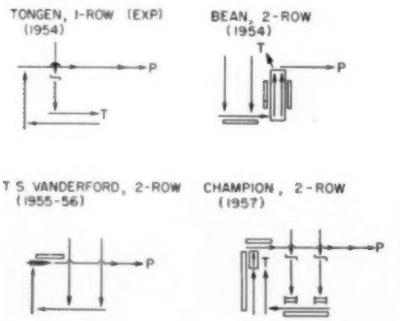
(See page 66 for explanations of machines diagramed below)



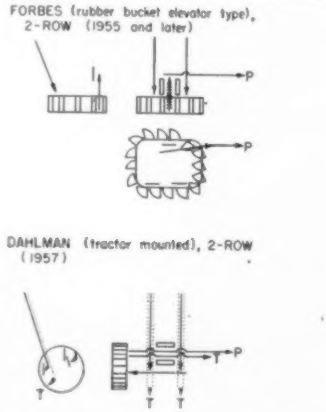
Flow diagrams: 1, upper left; 2, upper right; 3, lower left; 4, lower right.



Flow diagrams: 5, upper left; 6, upper right; 7, lower left; 8, lower right.



Flow diagrams: 9, upper left; 10, upper right; 11, lower left; 12, lower right.



Flow diagrams: 13, upper; 14, lower.

SYMBOLS

= End View of Conveyor
= Single Lane Rod Chain Conveyor
= Two-Lane-Flow Conveyor
= Flighted Rod Chain Conveyor
= Platforms for Hand Sorters
= Single Devining Roller
= Double Devining Rollers
= Drop Between Consecutive Conveyors in Tandem
Top View Side View = Wide Spaced Rod Conveyor For Vines Above Standard Pitch Chain
= Hinge in Conveyor
= Roller Conveyor
= Belt Conveyor
= Tumbling Drum
= Crossover
P = Potato Delivery
T = Tare Delivery

FIGURE 3. One of the advantages of the "indirect" method is that fields can be "opened" for working in "lands" without driving any equipment on undug rows of potatoes. The machine in this photo is picking up a two-row windrow. The flow diagram for this 1952 John Bean machine is No. 4.

FIGURE 4. A two-row Dahlman harvester with a flow plan as illustrated in flow diagram No. 5.

FIGURE 5. This Lockwood 1957 self-propelled model is similar in general flow pattern to the 1954 model shown in diagram No. 7. The 1957 model has double-roller double-belt deviners (at the delivery end of each primary apron) instead of the single roller deviners, and also has a 12" laterally tilted apron at the rear edge and parallel to the cross-over bulk loader.

FIGURE 6. This Dahlman model TM, also represented by its flow diagram No. 14, was introduced to growers in 1957. The advent of this model may be most significant because of its indication of a trend toward more self-propelled models, tractor-mounted or semi-mounted models in the future.

ments in design and in details of construction, and more careful operation the indirect method was demontsrated to be widely adaptable, able to deliver quality potatoes with high capacity and economically competitive with heavier and higher priced two-row direct machines.

Devining Accessories. The widely different practices or preharvest treatments applied to potato vines in various areas impose greatly different requirements or conditions to be met by devining accessories. Two or even three different clear-cut functions may be required: (1) loose vine separation and disposal, (2) stripping or detachment of clinging immature tubers from green vines, and (3) the separation of root clumps and other soddy material or weed growth. The material to be separated may range in conditions from dry and brittle to green, tough and fibrous with a tendency to wrap.

Three general types of devining units have been widely tried and used in the U.S. These are: (1) air blast, (2) wringer rolls or belts, and (3) wide mesh chains. The last has also been one of the most widely used types in a large assortment of European potato harvesters. Air blast alone or sometimes in combination with other mechanisms has been a feature in at least three experimental machines in North Dakota. Their effectiveness depends on the dryness of the material to be separated which makes this type more likely to be effective in dry climate areas. They have gained limited acceptance in several limited-production machines built in Idaho. In some cases air blast accessories are optional for a 2-row harvester at an added cost of about $500 for a fan unit and the larger power supply.

The type referred to as the wringer roll type is probably the most widely used in this country and have been used, or is being used experimentally on the greatest number of different makes of harvesters. This includes single rubber rolls operating against the primary apron just below the delivery point and double rolls, with or without belts, operating in the same general location. Smooth surfaced thick rubber rolls (generally about 3½" to 4" in diameter on a 1" steel shaft) in pairs are the basic components in many of these wringer type units. When these were found to be subject to wrapping with long vines etc. they were succeeded by designs having similar sized steel or rubber rolls enclosed in wide short belts. The circumference (length) of these belts was limited by the space available but were generally long enough to prevent the wrapping of shorter vine material and to reduce the tendency for wrapping of longer material. The build-up of soil often experienced on rollers without belts was reduced by the use of belts but since it is difficult to exclude all soil from getting inside the belt some build-up on the rollers has persisted and interferred to some extent with keeping the belts centered on the rollers.

Some designers have been experimenting with wringer type deviners in other locations on the machine and the use of additional accessories for delivering vines to the wringers by an air blast or by some other means, in order to avoid the passage of soil, stones and all of the potatoes directly over the wringer rolls or belts. Observations on these designs to date have indicated certain limitations in their adaptability to certain conditions.

The principal merit of the wringer type deviners is their effectiveness in stripping tightly clinging immature tubers from vines and root clumps. Their adaptability to extremely heavy untreated or unmutilated vine growth, very weedy or very stony conditions, has not been fully satisfactory. Further improvements may be made or other types or loca-

tions may ultimately prove more satisfactory.

Ideally the devining function should be done as early in the sequence of functions as possible—over the blade or above the front of the primary apron would seem to be ideal. It is often desirable in different areas to leave the entire vine growth without reduction until actual time of harvest either for its protection against frost or hot sun. This favors the incorporation of the devining function in the harvester or in the digger-windrower rather than in a separate machine for preharvest use.

The location of wringer type devining mechanisms at other points than below the delivery point from the primary or secondary apron, the use of other methods and arrangement of feeding the vines into the rolls are generally experimental and too diverse to be satisfactorily included in this general discussion.

The use of wide-mesh aprons, with cross members far enough apart to allow potatoes to drop through, has been tried extensively in this country and also in Europe. This type has been under development and limited use for about 10 years or more. It might have reached greater popularity except for the advent of rotobeaters and other types of preharvest vine mutilators which reduce the vines to pieces generally too small to hairpin or carry over on the wide mesh bars. This type is best adapted to conditions of heavy vine growth, weedy or soddy conditions and where the tubers are not clinging too tenaciously to the vines.

Methods and practices for the purpose of preharvest vine killing (chemical) applications, mechanical mutilation or undercutting produce such widely different physical results that the method used may dictate the type of auxiliary devining mechanism to be chosen, or to be eliminated from consideration. Further developments or standardization of preharvest practices may determine the future development of devining accessories for harvesters or possibly relieve the harvester of this function. The further development of more successful vine pullers might do this.

Experimental development aimed at improved deviners is quite active and the present status of full vine elimination as a function of the harvester may be subject to considerable further evolution within the next three or four years. Some devices being used in current European machines may be improved to a point for competitive consideration in this country.

Clod and Stone Separation. Most of the mechanical separation in current harvesters is by sifting action through rod aprons. Other sifting actions by the use of rotating drums of assorted designs, rotating tilted grids, oscillating bar grids, laterally tilted or steeply inclined belts or aprons. Liquid flotation, air blast, and vacuum systems also have been widely tried for auxiliary separation of potatoes from firm clods or stones.

Some degree of success has been attained with rotating drums (these have been more widely used in Western Europe than in the U.S.) but when there are many harsh clods or stones too large to be sifted through the primary aprons, potatoes may suffer excessive amounts of small injuries. The rotating drum design seems to have only limited adaptability as compared to laterally titled aprons or belts which have come into extensive use in this country. This feature is of greater advantage for round varieties and less suitable where long varieties are grown almost exclusively. The better adaptation of round shapes to mechanical handling in harvesters and in most subsequent storage, handling and sizing operations is an incentive in the search for varieties more satisfactory in all respects. To be an ideal

variety of potatoes should have the usual qualities demand such as: consistently high use qualities, attractive appearance, consistently high yield, etc., and *also good physical handling qualities*. It should be remembered that a round potato can be retained on an apron of wider pitch and greater separating capacity than a potato of the same weight and any other regular shape. This is at least as important as the rolling quality or rollability of the round potato for separation on inclined conveyors.

Two or three other methods of cleaning by crushing or milling action for clod reduction deserve mention. The most widely used of these is the multiple rubber roller table, previously mentioned under "General Machine Design and Evolution" page 58 which attained its highest development and significant acceptance in Idaho. The multiple roller design was found less suitable for use in areas where soils are heavier and more rainfall is to be expected during harvest and where, due to the varieties grown and to harvest conditions, skinning is more likely to be a problem. Another idea was to crush clods on the primary apron with a softly padded or pneumatic cushioned drum rolling over the material as it was elevated on the primary apron. One builder has featured an additional apron operating on top of a rather conventional primary apron so that the potatoes, clods, and other material are elevated between two chain aprons. In this design the upper and lower aprons can be operated at matched speeds where there are no clods, or, by means of a variable speed drive to the upper apron, it can be operated at a slightly greater speed to produce crushing action on the clods.

The two most widely used and most versatile methods of clod and stone separation in use in current potato harvesters are (1) sifting and (2) rolling action on one or more tilted conveyors. (Tilted laterally with respect to direction of conveying.) The angle of tilt is now readily adjustable in several models. Greater angle of tilt is necessary with the rod apron than for flat belts to give the same amount of rolling action. Between rod aprons of different pitches (or different net clear space between rods) the smaller the pitch the greater the rolling action at any given angle of tilt.

Tilted conveyor, or lateral roll separation has wide utility and is now well established as a feature of wide utility. It is particularly well adapted to round varieties of potatoes and its popularity will exert a long time influence toward varieties of potatoes of more rounded shape.

Transfer into Hauling Containers. An alert and conscientious operator using a harvester with power hydraulic controls can deliver the potatoes into hopper type bulk truck boxes with very gentle handling and generally with less tuber damage than is done by hand pickers in filling bags, barrels or crates. Accessories for filling bags or other small unit handling containers on a harvester may be the limiting factor in machine capacity. The use of small size handling containers such as 100 lb. or 120 lb. bags, crates, or barrels require more physical effort. Arduous labor and heavy lifting are almost eliminated by bulk handling. The advent of bulk handling was an important step advancing mechanization to the present efficient potato harvesting machines capable of reducing harvesting labor by 60 to 80% of requirements by methods most common 8 to 10 years ago.

The intermediate size handling containers such as "pallet" boxes of approximately 1-ton capacity are more difficult to fill without dropping part of the potatoes through to great a distance when beginning to fill the containers. Further improvement in

methods, equipment, or techniques are needed in order to make the field filling of pallet boxes directly from the harvester more acceptable. These improvements may involve changes in the design of the harvester, its accessories, the carrying vehicle, or the handling containers.

Looking Forward

In appraising the current status of potato harvester development it might be described as having now reached an early stage of maturity. It has progressed through several years of rapid development and relatively wide acceptance by growers. There has been some degree of standardization but there are still many differences. The several wider differences in current designs, the present activity in making changes and further adaptations to areas where mechanical harvesters are relatively new, and the prospect for further development seem to indicate that current designs have not yet reached full maturity but that changes will probably continue through the next decade at a slower rate.

In areas where the various individual makes or models have proved their adaptability the savings to be gained, by a change from hand methods to full mechanization, are great enough to be made without hesitation. If the individual acreage involved is between 25 and 40 acres the grower may well consider a rebuilt or used model of one of the more simple designs. As the individual acreage exceeds 40 acres the alternative will lie between: a later model, a larger more elaborate one, or one of the latest current models. Under a wide range of conditions these current production machines have capacities of 250 to 00 acres per season.

EXPLANATION OF FLOW DIAGRAMS (See page 59)

Flow diagrams 1 to 4 inclusive represent the earlier models of one-row harvesters. None of these had devining mechanisms. Flow diagram No. 3 shows a double-lane tilted belt for separating potatoes from less easily rolled-materials. Since 1952 the rear cross conveyor in diagram No. 2 has also been tilted (toward the rear). This gives two-stage "fractionation". (See also Figure 3.)

In flow diagram No. 5 the two conveyors delivering toward "T" are tilted clod eliminators. Potatoes must roll or be rolled completely across these to be carried into the truck by the bulk loader.

The double-roll (with belts) deviners (shown in flow diagram No. 6) were incorporated in the two-row Champion harvesters in 1952. Similar devices have been incorporated more recently into other makes to an increasing extent. The single roll type of deviner in diagram No. 7 has had a longer use history, but to a certain extent has been displaced by the type with double rolls and belts.

The tumbling drum-type of separation indicated in diagram No. 8 has been tried in many places but has gained less acceptance in the U.S. than similar machines in Europe.

Diagram No. 9 represents the flow in an experimental harvester for indirect operation which has achieved significant success in picking up a 4-row windrow.

Diagram No. 10 is similar to No. 4 except that it can be used for two-row direct operation.

Diagram No. 11 represents a very short coupled design developed by a grower in Idaho.

Diagram No. 12 shows a 1957 model of a general design which has remained much the same for six years. The forward flow on the left side, with crossover bulk loader, contribute to high capacity with good lateral weight distribution. The "split" aprons are an extra cost option.

Flow diagram No. 13 shows side elevation (left), plan view (upper right), and rear view of a machine which features a vertical elevator utilizing molded rubber buckets. It is a relatively short coupled machine. The potatoes are elevated in the buckets at the right side which deliver the potatoes at the upper level on a multiple rubber roll cleaner which in turn carries them forward to the bulk loader.

A relatively recent development is shown in flow diagram No. 14 and Figure No. 6. This machine features a wide spaced rod deviner chain completly enclosing the primary apron, and a revolving drum for cleaning and elevating.

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Many of our readers have occasion to write to the various State Agricultural Colleges, Extension Service or Experiment Stations concerning potato or onion problems. For this reason we are listing the names of the State Directors.

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Walsh, North Dakota
Bingham, Idaho
Pembina, North Dakota
Grand Forks, North Dakota
Bonneville, Idaho
Polk, Minnesota
Rio Grande, Colorado
Scotts Bluff, Nebraska
Clay, Minnesota
Weld, Colorado
Jefferson, Idaho
Steuben, New York
Lehigh, Pennsylvania
Fremont, Idaho
Accomack, Virginia
Monmouth, New Jersey
Twin Falls, Idaho
Klamath, Oregon
Cameron, Texas
Madison, Idaho
Tulare, California
Baldwin, Alabama
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Bay, Michigan
Yakima, Washington
Mercer, New Jersey
Penobscot, Maine
Langlade, Wisconsin
Cassia, Idaho
Montcalm, Michigan
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San Joaquin, California
Riverside, California
Dade, Florida
Marshall, Minnesota
Nassau, New York
St. Johns, Florida
Clark, South Dakota
Presque Isle, Michigan
Traill, North Dakota
Freeborn, Minnesota
Canyon, Idaho
Erie, Pennsylvania
Northampton, Pennsylvania
York, Pennsylvania
Minidoka, Idaho
Modoc, California
Schuylkill, Pennsylvania
Saguache, Colorado
Crook, Oregon
Benton, Washington
Hartford, Connecticut
Wyoming, New York
Charleston, South Carolina
Grant, Washington
Norman, Minnesota
Oneida, Wisconsin
Conejos, Colorado
Monroe, New York
Deschutes, Oregon
Burlington, New Jersey
Erie, New York
San Bernardino, California
Kittson, Minnesota
Kittitas, Washington
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Genesee, New York
Marathon, Wisconsin
Alamosa, Colorado
Worcester, Maryland
Box Butte, Nebraska
Hennepin, Minnesota
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Potter, Pennsylvania
Beaufort, North Carolina
Somerset, Pennsylvania
Santa Barbara, California
Wayne, New York
Wayne, North Carolina
Bannock, Idaho
Camden, North Carolina
Hampshire, Massachusetts
Morrill, Nebraska
Gooding, Idaho
Onondaga, New York
Pasquotank, North Carolina
Washington, Rhode Island
Columbia, Pennsylvania
Siskiyou, California
Deaf Smith, Texas
Berks, Pennsylvania
Cambria, Pennsylvania
Maricopa, Arizona

1957 Potato Production

THE 1957 production of *fall* potatoes is placed at 155,780,000 hundredweight, 7 percent below 1956 but 4 percent above the 1949-55 average. The increase of 4,894,000 hundredweight during October was mostly in Maine and Idaho. However, there were small increases in a number of other fall States. October was generally favorable for the late development of potatoes in most fall States. Harvest was practically completed by November 1 in all States except Minnesota, North Dakota and the Tule Lake area of California where rains in October delayed harvest.

The production in the 8 Eastern fall States at 60,293,000 hundredweight is 7.5 million below 1956 and 0.9 million below the 7-year average. In the Central fall States, production at 33,968,000 hundredweight is 7.3 million below 1956 and 4.8 million below average. The Western fall States at 61,519,000 hundredweight is 3.9 million above 1956 and 11.6 million above average.

In Maine, harvest was completed without significant damage to tubers from frost. Quality of the Maine crop is good. Soil moisture was adequate throughout the season; however, the artificial killing of tops kept yields below record levels. In other New England States, yields are near record high levels. In Upstate New York, the dry cool weather in October was suitable for harvest and digging was mostly complete by November 1. On Long Island, yield and quality were good with digging nearing completion. Movement of Long Island potatoes during October was slightly heavier than during October last year. All sections of Pennsylvania enjoyed good harvesting weather and digging progressed rapidly during October. A few growers reported light yields due to spotty rainfall during the growing season but yields in the northwest part of Pennsylvania were mostly good.

In Ohio, Indiana, Michigan and Minnesota, yields were above earlier expectations. In the Red River Valley of North Dakota and in Minnesota, potato digging has been delayed by inclement weather. On November 1, possibly 15 percent of the acreage in the Red River Valley remained to be harvested. However, growers were still hopeful that they could dig a part of this acreage.

In Idaho, the late fall and prolonged excellent harvest weather combined to give producers a bumper yield of potatoes. Temperatures during the growing season were favorable for smooth quality potatoes. All the crop was under cover by November 1 except for a few stragglers. In the San Luis Valley, Colorado, harvesting is reported to be nearing completion although some delay during the past three weeks was experienced as a result of frequent rains. In Oregon, potato harvest was virtually completed by November 1 although a few hundred acres were still out in central Oregon. The Klamath County crop was under cover before extensive freezing occurred. Potato digging in the Tule Lake area of California is lagging slightly.

The 1957 production of other seasonal groups, with 1956 in parentheses, are as follows: *Late summer,* 32,213,000 hundredweight (33,967,000); *early summer,* 8,843,000 hundredweight (9,503,000); *late spring,* 28,610,000 hundredweight (24,330,000); *early spring,* 4,243,000 hundredweight (4,022,000); *winter,* 6,810,000 hundredweight (5,260,000).

The *1958* acreage for *winter* harvest in Florida and California is placed at 37,500 acres—7,500 acres below the 1957 harvested acreage but 13,500 acres above the 1949-56 average of

24,000 acres. Florida's acreage was decreased by 31 percent from last year while California acreage is unchanged from the previous year. In Dade County, Florida planting started the last week of October. In the Palm Beach area, planting was mostly complete by November 1. In California, the crop appears to be progressing satisfactorily but much of the acreage in Tulare and Fresno Counties was planted later than normal.

A New Box Tipper

By Alfred D. Edgar

USDA researchers have developed a 1-ton pallet box tipper that gives promise of reducing labor costs and quality losses in handling potatoes and other commodities. The work was done at the Red River Valley Potato Research Center, East Grand Forks, Minnesota.

The tipper consists of a motor, pump, hydraulic cylinder, and a strong frame to handle the ton-capacity boxes. It requires 3 or more 4-foot sections of gravity roller conveyors.

Box storage has always seemed promising because it reduces the number of handling steps. This is so particularly when potatoes have to be conditioned, as for potato chips. But in the past, handling costs have been high and potato injury in filling boxes has been excessive.

Boxes are fed onto and off the new tipper along the conveyors. The tipper cradles and tilts the boxes and does not damage them during filling and emptying operations. A conveyor moves the potatoes from the bulk truck to the boxes. The boxes are lowered gradually as filling progresses, to prevent excessive dropping and potato injury. The tipper can also be used to empty the boxes onto a conveyor.

It takes only 3 minutes to place, fill, and remove a box from the tipper to storage. This permits a fork-truck operator to transport, stack, and unstack boxes while others are being filled. He can unload a 200-bushel bulk truck in 15 minutes.

In an effort to improve the handling and storing of potatoes the Department of Agriculture has been comparing the use of bulk bins with boxes.

Handling and storing white potatoes in pallet boxes was initiated in 1944. Since that time it has been found that these boxes, which can be filled in the field or at storage, have a place in the potato industry.

Various methods have been used to fill the boxes in the field. Probably the best method has been to carry boxes on a pusher trailer which enables the driver to keep the boxes directly beneath the discharge part of the harvesting elevator. Handled otherwise, potatoes hit the tops of the boxes, causing excessive bruising.

Loading boxes with potatoes from bulk harvest trucks started in 1953. Originally these boxes were tilted on a light frame by elevating one side with an overhead hoist. It required 50 minutes to empty a 200-bushel load—too slow to be practical.

Potatoes may be loaded into boxes in the field, or into bulk trucks and then brought to storage to be loaded into boxes. If they are loaded into boxes in the field and brought to storage, it usually takes a fork-truck operator $3\frac{1}{2}$ to 4 minutes to pick up and stack a full box and return with an empty box to the trailer. But it only takes 3 minutes to place, fill, and remove a box from the tipper. Therefore, a field-to-storage motor truck would be delayed less in filling 6 boxes from bulk than if 6 field-filled boxes were removed from the truck and stacked and 6 empty boxes placed in the trailer.

The new box tipper seems to have commercial possibilities where perishable agricultural products are to be stored and handled in pallet boxes. Tilting boxes to fill them results in less drop. Tilting to empty boxes is probably more practical than using boxes with hinged bottoms, especially when storage boxes are filled only once or twice a year.

Mr. Edgar is Senior Agricultural Engineer, Transportation and Facilities Branch, Agricultural Marketing Service, U. S. Department of Agriculture.

Box Handling and Storage of Potatoes

The U. S. Department of Agriculture in cooperation with the Minnesota and North Dakota Agricultural Experiment Stations conducts potato handling, storage and marketing research at the Red River Valley Potato Research Center, East Grand Forks, Minnesota.

The regular potato storage project work of the U. S. Department of Agriculture has included observations on bushel box storage since 1931, on ton box storage since 1944 and on quarter ton box storage since 1952.

The ton potato and union boxes used at Keenesburg, Colorado in 1944, are pictured in a USDA film that was quite widely shown. The filling of these ton capacity, 4 feet deep boxes, has been quite a problem because of injury. This injury was reduced in the quarter-ton capacity 18 inch deep box, which could be carried on a truck and filled from a regular harvester.

It was impractical to stack these boxes 2-high to get a paying load so the harvester elevator was lengthened and equiped with a canvas chute for filling ton boxes. A workman handling the chute can reduce injury in filling boxes.

Unless some automatic method of keeping boxes and conveyor in register is developed, filling boxes on truck at side of harvester depends too much on ability of drivers to get uniformly good results.

Large boxes have been used to handle potatoes from truck to the bottom of deep bins. The hairpin fork supported by a hoist on a track, was tried, but was too clumsy for efficient operation.

But the top grab, patterned after the Maine barrel grab, proved practical with boxes having the 2″ x 4″ top rail on 2 sides. This looks well both for dumping and other box handling within reach of an overhead track.

A comparison was made of boxes filled on the truck by harvester and those filled at the storage from bulk trucks. These boxes were tilted in filling by resting one side on a simple tilting frame and raising the other side with an overhead hoist.

When dumping boxes with overhead hoist and top grab there was considerable flow of potatoes over grab until half of the box was covered.

It is possible that the overhead track, hoist, and top grab make it practical for the small operator to use large boxes for loading, unloading, and dumping.

A comparison of the potato shrinkage in box storage has been made of: (1) Hand and machine harvested; (2) potatoes conveyed over dirt screen and those field run; and (3) those in slatted and tight boxes. They were weighed with the top grab and dial scales.

The Sam Kennedy & Sons 4,000 unit ton-box operation at Clear Lake, Iowa, is one of the earliest box developments. The USDA has been privileged to observe it from the first and did some experimental work there in 1952-1954.

Kennedys have probably done more than anybody else in trying methods of harvesting into ton boxes. No one is entirely satisfied with methods so far developed in filling boxes from the harvester.

Box handling and storage of agricultural crops has followed industry in many aspects. The outside hard stand seems to be as important for empty agricultural box storage as in industry.

The Kennedy boxes have been stacked 5 high. Some operators question the overall economy of high stacking. While more potatoes can be put under a given roof area, a 20 foot wall costs more per unit of height than a

16 foot wall, and other costs, hazards and labor go with the higher stacking.

Is extra potato injury a serious factor in conveying potatoes from hoppers? A one box capacity hopper is shown. One operator uses a 3 box capacity hopper to improve the gas fork truck operating cycle.

The tilting-head fork truck used for dumping boxes put considerable strain on the boxes in dumping unless side retaining arms are used. Side arms interfere with removing boxes from closely spaced stacks.

Kennedys hardwood boxes take the strain of dumping much better than the USDA experimental glued softwood boxes.

Onion boxes with slatted bottoms and flaps were used in the forced air circulation work. This was expected to channel air upward through stacks. The flaps were more trouble than they were worth.

There has been quite a controversy over the suitability of slatted and tight boxes. Tight sided boxes with slat bottoms are satisfactory when air is forced up through the potato, onion or apple box and tight bottoms, where circulation is by convection between box top and product.

In 1954 the Emmet County Potato Growers built a 2000 unit ton-box storage and conditioning warehouse at Levering, Michigan, after consulting with the Michigan Experiment Station, The New Era Chip Company, and the USDA.

Here a wall plenum was used with slots opposite every second pallet opening. Slat bottom boxes were used. Conditioning air is forced from the wall, up and down through the boxed potatoes and out the open pallet space at the alley. Good regulation at low static pressure is secured.

At the Levering, Michigan storage, field-run potatoes are stored in boxes in the low temperature holding room. A schedule of movement from this room to allow conditioning to fit market demands is maintained. The moved boxes are dumped over a packing line: part are discarded; part go for the table stock; and part back into boxes for conditioning.

The conditioning room is held at 60° to 80° depending on the history of potatoes and speed of conditioning wanted. Naturally the potatoes sprout when held beyond their dormant period at such high temperatures.

At the Research Center Farm in 1954 a 3-box trailer was used. The top of the boxes were 64" above the ground (empty) and 58" when full. This is about 30" lower than the box top height on trucks so they could be filled on a trailer from standard harvester elevator. The man on the trailer introduced white potatoes for injury studies.

After trying unsuccessfully to keep the trailer in register with the elevator, an attachment was made to the front of power wagon and the 3 box vehicle was pushed. With a little practice this worked out very well. However, filling boxes with an unattended chute resulted in 8% major potato injury. With potato loss valued at ½c per pound, an $8.00 per day workman on the chute would have been worth $25 to $50 a day.

Filling boxes on low trailers by hand pickers appears to be a practical method for the smaller operator. With a man on the trailer dumping baskets, less potato injury (estimated from 1% lower shrinkage) occurred than when boxes were filled from the harvester.

Hand lift trucks can be used to handle boxes to and from trailer, if the rear end of trailer is supported level with the floor. With a $200 to $300 hand truck and a smooth storage floor, it is possible to handle and hold in storage small amounts of potatoes in boxes at low equipment cost.

Large box storage work at the Research Center received quite a boost when Jno. C. Rill of the Western Fruit Express arranged to loan the Station

a fork truck equipped with dual pneumatic tires so it could be used outside on gravel as well as on concrete.

The overhead hoist box tipper used for filling boxes from bulk trucks required 50 minutes to fill and move 6 boxes from a 200 bushel bulk load. The hydraulic tipper with roller conveyors for lateral movement of boxes cut this time to 20 minutes.

Potato drop can be reduced to a maximum of 6" to 12" by tilting boxes up to conveyor for filling.

Since 1944 when ton potato boxes were first used in USDA potato handling and storage experiments many materials, types, and variations have been tested. The 4' cube seems to be about the best size.

The Douglas Fir Plywood Association furnished exterior 3/8", 1/2", and 5/8" plywood for several boxes in 1952. These were secured to a frame with nails and resorcinol resin adhesives. They are good, but relatively expensive.

After John Ladd and G. A. Thompson of the General Box Company consulted at the Research Center on the requirements of potato storage and handling boxes, they had 6 wire-bound boxes built to test there.

The box must: (1) Be strong enough to contain potatoes and support 3 or 4 tons stacked on top of it: (2) have skids or pallet to fit the handling equipment and to provide an area of contact between stacked boxes; and (3) be built to withstand wracking loads while being tipped if external support is not provided.

The wire-bound boxes had only the 4 x 4 inch side rails when first made as bottom facing was not needed on the box tipper.

However, the bottom face was added to adapt them to the gravity roller conveyor system presently in use. A slight modification of conveyor spacing would make the bottom face unnecessary.

Visitors to the Research Center generally remark that box handling and storage looks good but expensive. The plywood ton boxes cost about $20; the board boxes $13 to $20; and the wire-bound, $12.50.

Better quality but more expensive storage and handling is possible with bushel boxes. Unless ton box handling produces extra quality to pay for extra cost, it is going to be a job to promote ton-box handling and storage in competition with 1000-ton bins.

A 120,000 bushel or 3600 ton capacity bulk potato storage cost $38,000 complete. It has automatic ventilation regulation; provisions to handle into storage; 6 inches of insulation; and fireproof construction. Some think that by eliminating the bins enough can be saved to buy boxes. But, 3600 wire-bound boxes at $12.50 each would cost $45,000. To pay their way boxes must reduce labor or injury or both.

Shipping Potatoes in Subzero Weather

A WINDPROOF canvas tunnel enables shippers to load potatoes from warehouse to refrigerator car in subzero temperatures without danger of frost injury. This economical device, developed by the U. S. Department of Agriculture in cooperation with the Red River Valley Potato Growers' Association, University of Minnesota, and North Dakota Agricultural College, is helping to relieve the shipping problem that has occurred in the cold North Central States.

Up to now, railroads discouraged shippers from loading at temperatures below —5°F., because of the excessive number of claims they got for frost damage to potatoes in transit. These restrictions have been costly to potato shippers too. They are unable to supply customers regularly and they cannot "cash in" on seasonal price peaks.

Investigations revealed that wind was the key factor in frost injury to potatoes moved from warehouses to preheated refrigerator cars in subzero weather. In —20° weather a little wind pulls 2° of heat a minute from the inside temperature of preheated refrigerator cars.

The tunnel is fixed and held in place in the car door with an adjustable holding frame. These frames can be bought or may be homemade. Canvas, 15- or 20-ounce, provides adequate wind protection.

The tunnel's circumference should be 27 feet at the car-door end in order to fit the several sizes of car doors. The warehouse end of the tunnel should be made large enough to fit the inside frame of the door to which it will be attached. The tunnel should be at least 1 foot longer than the distance between the warehouse and car doors. A folded edge sewed into the car-door-end with a half-inch rope drawn through it makes snugging into the car door with the adjustable holding frame easy.

Danger from carbon monoxide gas is always present in any refrigerator car using a charcoal heater. The windproof tunnel adds to this danger so two men should be working together in servicing and loading these refrigerator cars. If at all possible, and if weather and carrier permit, a little opening should left between the top of the canvas tunnel and the top edge of the car door.

Potato Memorial

A Committee on a National Potato Shrine aims to erect a memorial to the most important vegetable, at the place where the potato industry of America was born, in Londonderry, N. H., in 1719. Substantial pledges of money have been made by potato growers, and other friends of the spud have made donations and pledges. Land has been given for a memorial by Mrs. Caroline M. White who owns the Murdock Farm on the Derry Bypass containing the actual field where the potatoes were grown which, through use of their seed, became the ancestors of today's vast American white potato industry. The community which included the first potato acres was known as Nutfield and the field itself is close to West Running Brook. Robert Frost was born only a few miles down the road and many of his poems have immortalized the fields, orchards, brooks and uplands of this corner of New England.

10 New Potato Varieties Tested

How 10 of the newer potato varieties held up during 1957 field trials at University of Wisconsin branch agricultural stations at Hancock and Spooner is reported by UW horticulturist John Schoenemann.

Antigo is a round, white variety recently released at Wisconsin. It is medium-early, average yielding and has excellent scab resistance, Schoenemann said, and has adapted to a wide range of soil types and growing conditions.

Delus, a medium-late, white variety, is reported good for potato chips. It is resistant to late blight and has good cooking quality, the UW expert said, but it has some tendency toward rough tubers and is extremely susceptible to seed piece decay.

Early Gem is an early, long russet potato. It is resistant to scab and has an average yield, Schoenemann reported, adding that it tends to crack on heavy soils and has fair cooking quality. Market demand is good, but it is not widely adapted.

Keswick, a medium-late, round, white potato, is resistant to late blight, is a high yielder and has excellent cooking quality. The variety comes from Canada, but shows promise in Wisconsin, Schoenemann said.

Red Beauty is a high-colored red variety newly released by Wisconsin. Tubers are smooth. It has good yielding and cooking quality.

Red LaSoda is a mid-season, red variety. Tubers are smooth. The variety tends to set light and it is subject to scab. Cooking quality is fair to good.

Rushmore is a long white variety developed in Louisiana. Tubers tend to set high. This means a tendency toward greening unless the crop is well hilled. It yields well and has excellent cooking quality.

Saco has just been released by Maine. Tubers are short and round with some roughness. This variety is high yielding and adapted for potato chipping.

Sheridan is a round, red potato developed in Nebraska. It tends to set heavy but is susceptible to late blight and scab.

Tawa is a new variety from Iowa. It is early, white and resistant to scab, late blight and mild mosaic. Chipping quality is good. It is adaptable to various locations in Wisconsin.

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